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Addis Ababa University College of Natural and Computational Sciences

Department of Zoological Science

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Biology On the **effects inorganic fertilizer application on the infestation of *striga hermonthica*, on the growth and yield of sorghum bicolor in Mertulemariam town, East Gojjam Zone, Amhara, Ethiopia**.

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Addis Ababa, Ethiopia

APPROVAL SHEET

Title: The Effects of inorganic fertilizer application on the infestation of striga hermonthica, on the growth and yield of Sorghum bicolor in Mertulemariam Town, East Gojjam Zone, Amhara Regional State.

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Declaration

The researcher hereby declares that the thesis entitled; “The Effects of inorganic fertilizer application on the infestation of striga hermonthica, on the growth and yield of Sorghum bicolor in Mertulemariam Town, East Gojjam Zone, Amhara”, submitted by the researcher to complete the paper of MSc in biology is his original Work and has not been submitted earlier. All sources that have been referred to and quoted have been indicated and Acknowledged with complete references.

Name Habtamu Sirie Sign ________________ Date ______________

This thesis has been submitted for examination with my approval as the university advisor.

Advisor Name: Dr.Awol Assefa Sign ________________ Date_______________

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Contents

The Effects of different concentrations of inorganic fertilizer application on the infestation of striga hermonthica, on the growth and yield of Sorghum bicolor in Mertulemariam Town ,East Gojjam Zone ,Amhara Regional State .

By: Habtamu Sirie Yalew Addis Ababa University, 2024G.C

Abstract

Sorghum [Sorghum bicolor (L.) Moench; 2n = 20] is the fifth most important crop planted worldwide, after maize, rice, wheat, and barley. It is mostly farmed in semi-arid tropical regions for food and fodder .Sorghum is a significant food crop in Central America, South Asia, and Africa (Sorghum bicolor (L.) Moench, Poaceae). Due to the striga species' ability to parasitize new crops or types and adapt to changing environmental conditions, the problem caused by infestation is predicted to get worse. Is it possible to enrich the soil to lessen striga weed's effects on yellow sorghum growth and yield? This study's main goal was to determine how different inorganic fertilizer concentrations affected the growth and yield of sorghum bicolor while striga hermonthica was present. To develop effective strategies to mitigate the effect of striga weed on the productivity of yellow sorghum. Ha: There are differences in the effects of varying fertilizer application concentrations on striga hermonthica infestation as well as on sorghum bicolor growth and production. One of the main production barriers in Ethiopia's sorghum-growing regions is Striga hermonthica (Del.) Benth (Scrophulariacae), which is made worse by the region's intrinsic low soil fertility, recurring droughts, and ongoing grain monoculture. Two varieties of Sorghum bicolor Bachete and wagere stratified with different ratings of fertilizer 0, 25, 50, and 100% fertilizer. Growth parameters were plant height, leaf number, internodal length, root collar diameter, seed number, seed weight, panicle size, and biomass were determined. The treatments were laid out under RCBD with three replications. Improved sorghum variety Wagere adapted to the area was used. The treatments (T) were (T1) no fertilizer +striga +Bachete variety as control (T2) 25% fertilizer +striga +Bachete variety (T3) 50% fertilizer +striga +Bachete variety (T4) 100% fertilizer+striga+Bachete variety (T5), no fertilizer+striga+Wagere variety (T6) 25% fertilizer+striga+Wagere variety (T7) 50% fertilizer+striga+Wagere variety (T8) 100% fertilizer+striga+Wagere variety. According to the current results, the maximum average grain yield and total biomass, head weight, and plant height were recorded prominently in plots treated with inorganic fertilizer. Generally, this experiment showed that productivity of sorghum is considerably higher when farmers use integrated soil fertility management options. Furthermore, integrated use of inorganic fertilizers *proved to be highly effective in terms of reducing Striga incidence, both in terms of reduced seed density in the soil and decreased infection in sorghum. Based on the results obtained, it is concluded that application of inorganic fertilizer significantly (*$p \leq 0.05$*) improved almost all the early growth performances and yield components of S. bicolor. I will recommend local farmers use inorganic fertilizer and a striga-resistant variety of sorghum wagere to enhance crop productivity. The weed causes considerable reduction of early growth and yield performances of yellow sorghum grown in semi-arid, non-fertile areas of East Gojjam, Amhara Regional State.*

Keywords: Agronomic practices, Sorghum, Striga, Yield component

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LIST OF ABBREVIATIONS AND ACRONYMS

IL- Intermodal Length

LN- Leaf Number

LA- Leaf Area

ANRSBA- Amhara National Regional State Bureau of Agriculture

CSA- Central statistical Authority

DAP- Diammonium Phosphate

Ha- Alternate hypothesis

Ho- Null hypothesis

RCD- Root Collar Diameter

SSA=Sub-Sahara Africa

1. INTRODUCTION

1.1Back ground of the study

After maize, rice, wheat, and barley, sorghum [Sorghum bicolor (L.) Moench; 2n = 20] is the fifth most significant crop planted globally and is mostly grown in semi-arid tropical regions for food and fodder (FAO, 2019). Sorghum is a monocotyledon crop that spontaneously self-pollinates, with a degree of spontaneous depending on the type of panicle; cross-pollination can reach up to 30% in some instances (Begna, 2021). Sorghum is a member of the C4 family and has a high rate of photosynthetic activity. As a result, it is grown in practically all places with moderate and tropical climates (Dubey *et al.*, 2021). The source and roughly 5000 years ago, sorghum was first domesticated in northeastern Africa (Venkateswaran *et al.*, 2019). Sorghum is a grain that was first produced in Ethiopia, as well as variable rainfall, unfertile soils, and poor soil structure (Dahlberg *et al*., 2012).

Sorghum is a drought-tolerant crop that is crucial to Africa's food security (Hadebe *et al*., 2017). Since the early Holocene, when the Sahara desert was a green homeland for Nilo-Saharan tribes, the sorghum grain crop has been essential to the Sahel's adaptability to environmental change. Pursuing a way of life based on gathering wild grains and livestock herding or hunting (Bernal, 2020). More than 500 million people in Africa, Asia, and Latin America depend on sorghum as their primary source of food. Especially in semi-arid tropical regions of America, where food availability is severely restricted by drought production (Ejeta, 2007). Sorghum grain is used for human consumption in about two-thirds of the world's production. Consumerism in underdeveloped nations (Ejeta, 2007). In sub-Saharan Africa, where it is a staple crop, feed, and forage, sorghum is extremely significant for agriculture due to its adaptability to drought, heat, and low nutrient availability (Reynolds *et al.*, 2015). An economically significant cereal grain is sorghum. It is cultivated as a food crop in sub-Saharan Africa (SSA) by small-scale farmers (FAOSTAT, 2016). In impoverished areas of sub-Saharan Africa, sorghum provides food, fuel, and other essentials for humankind. Africa has weak soils, unpredictable rains, and other crops struggle there.

The sorghum crop has a fibrous root system that may permeate up to 8 feet into the soil to absorb crucial nutrients and water. It is also very productive and drought-tolerant. In Sub-Saharan Africa

(SSA), sorghum is a significant food staple, but the parasitic plant striga that clings to the roots of numerous cereal crops severely stunts and reduces output. Invasive plants of the Genus striga

are a significant barrier to the production of sorghum, especially in the drier regions of the world. Striga is a significant biotic barrier to cereal production in Sub-Saharan Africa's dry savannas. In Africa, where more than 100 million people live, this hemiparasitic weed reduces food productivity by half. The infestation of striga on roughly 64% (17 million hectares) of the cereal-planted land in West Africa reduces yields by 10 to 100%, depending on the crop and cultivar (Kebede Mamo, 2018). *Striga asiatica* and *striga hermonthica*, two parasitic plants, seriously reduce yield. Penalties for sorghum cultivation in commerce and for subsistence. An obligatory root parasite called Striga Seeds needs a chemical signal from a possible host plant in order to begin germination.

This parasitic plant spends the majority of its life cycle underground and only emerges above ground to produce stems and set seeds. It creates a haustorium during its underground life cycle, adheres to and enters the host root cortical cells, and suckers up nutrients, minerals, and water. From it and ultimately harm the life of the host (Ejeta, 2007). Production of sorghum and other grain crops striga, a parasitic weed, is a major constraint in sub-Saharan Africa that clings to the roots of cereal crops and severely stunts, necrotizes, and occasionally kills the crops that have a decreased yield (Ejeta and Gressel, 2007). Striga produces a lot of tiny seeds, but they do not germinate unless a sorghum, millet, or maize root develops extremely close to them in the soil. It is consequently exceedingly difficult to eradicate once it has been established, particularly in some regions where heavy infestation may result in complete crop failure in some years (Westwood *et al*., 2010). The issue as a result of striga is continuously rising as more continuous cereal is produced as a result of population pressures. Cultivation Striga favors poor fertility and unpredictable rainfall, which has an impact on small-scale farmers. Who are the least productive and able to afford any control inputs (Musyoki *et al*., 2015)?

Over 80% of the 30 to 35 species in the genus striga, which is a member of the Orobanchaceae, are found in Africa, with the remainder being in Asia (Westwood et al., 2012). Sorghum, maize, upland rice, and wheat are all infected by *Striga asiatica* and *striga hermonthica*, although tobacco and cowpea are infected by gesneroids (Ejeta and Gressel, 2007). *Striga hermonthica* is the most common, and this is due to an increase in farmed areas (Parker, 2009).

Monoculture, a favorable climate, sensitive host crops, and decreased soil fertility (Gressel, 2009*). Striga forbesii* and *Striga aspera* are known to have unpredictable effects on infected cereal crops within their habitats in addition to the more well-known Striga species (Westwood *et al*., 2012). Food security in sub-Saharan Africa is seriously threatened by the root parasitic plant Striga. The parasite is among the most dangerous types. Pests are reducing the yields of the three main cereal crops, sorghum, pearl millet, and corn (Ejeta, 2007). The parasitic nature of striga on sorghum and its detrimental effects on the plant's growth and grain yield had been shown for a long time by several academics. Bebawi and Farha (1981), for instance, claimed that the comparatively parasitic striga weed reduces sorghum grain yield by 32% but by 65% by weeds that aren't parasitic.

Due to the striga species' ability to parasitize new crops or types and adapt to changing environmental conditions, the problem caused by infestation is predicted to get worse. Striga, often notoriously known as witch weed, can completely destroy a crop's production (Ejeta, 2007). It In Sub-Saharan Africa (SSA), it is believed that more than 60% of farmland under cultivation is infested with one or more striga species, which affects the production of approximately 300 million farmers in over 25 nations and causes losses of more than $7 billion (Ejeta, 2007). According to estimates, Striga alone caused an annual yield loss of $7 billion in sub-Saharan Africa, posing a serious danger to the way of life for more than 100 million people (Teressa, 2019). Striga is a serious issue in Ethiopia's northern and eastern cereal-growing regions (Ayana and Bantte, 2019). Repeated sorghum farming on the same field increases the striga population to the point where it is unprofitable to continue. Area and degree of infestation due to some countries' ongoing grain monoculture growth are projected to rise in the near future. Regions of Africa, which combined with severe moisture stress and decreasing soil fertility has resulted in the weed hence being characterized as a sign of inadequate soil fertility (Tonito *et al*., 2016).

According to the agricultural extension workers of Enebsie Woreda, the yields of yellow sorghum cultivated in a specific area around Mertulemariam town called Eneguzy were estimated to be about 75 tons per hectare of land, and the yields of yellow sorghum cultivated in a specific area called Chinquire were estimated to be about 72 tons per hectare of land (source: Enebsie Woreda Agricultural Office). As a result of the rapid infection level of Striga weed, the yield of yellow sorghum in 1989 E.C. was reduced to 10 tons per hectare in 2000 E.C. The major reason that local farmers did not cultivate this species more was yield reduction of yellow sorghum. That was the reason they partially disappeared from Enebsie Woreda. Therefore, this study was conducted to evaluate the impact of Striga weed on the growth performance and yield of yellow sorghum.

The effect of inorganic fertilizer on striga in an effort to draw attention to this neglected and underutilized species, so it can contribute to the food security and income of subsistence farmers.

1.2. Statement of the problem

Sorghum is a significant food crop in Central America, South Asia, and Africa (*Sorghum bicolor* (L.)Pers, Poaceae). Only rice, wheat, barley, and maize are more significant cereal crops farmed for human consumption than sorghum (*Sorghum bicolor* (L.) Pers), which ranks fifth (Grover,2021).Around 44 million hectares of sorghum are thought to be grown globally, spread among 99 nations in Africa, Asia, Oceania, and the Americas. The top sorghum producers (in million metric tons) are (Komlaga *et al*., 2019). Between 40 and 45 million hectares are used to produce between 55 and 70 million tons of grain annually (Samuel Tegene *et al*., 2013). The most significant staple crop in Ethiopia is sorghum. With a total production of 4,339,134.261 tons, it was grown on 1,831,600.45 ha (CSA, 2015). It is among Ethiopia's top major food crops as well. In terms of overall production and second only to teff in the creation of "injera," it is ranked third in the nation behind maize and tef.cult undertakings (Ikie *et al*., 2006).

Striga is thought to be infesting around 21 million hectares of Africa's cereal production area, resulting in an estimated 4.1 million tons of grain lost each year (Ismaila *et al*., 2010). According to levels of infection, crop sensitivity, climatic factors, and soil characteristics, losses in grain production caused by Striga infestation range from 5 to 75% (Musango *et al., 2022*). Under severe infestation circumstances and dryness, vulnerable cultivars might have grain yield reductions of up to 100% (Peng *et al*., 2014).

According to Marenya *et al*. (2021), 25 different African nations reported striga infestations in 2005. Striga affects more than 100 million people in Africa and costs the continent's economy $1 billion US annually (Tadele *et al*., 2017). It is resulting in catastrophic yield losses in sub-Saharan Africa, restricting the availability of food in many poor countries (Nchanji *et al*., 2021). Farmers have reported losses ranging from 20% to 80%, and they are ultimately forced to abandon heavily infested fields (Kebede and Ayana, 2018). Under severe infection levels and dry circumstances, vulnerable cultivars can possibly experience 100% grain yield reductions

(Avelino *et al.*, 2015). The production of sorghum and pearl millet in West Africa is estimated to be contaminated with striga on 17.2 million acres.

Because of ongoing grain monoculture and inadequate input rates for organic and mineral fertilizers, the infestation area and level are predicted to grow in the future. S. hermonthica (Del) Benth. The main biotic barriers to crop production include *S.asiatica* (L.) Kuntze, particularly in the infertile semi-arid region of Africa, while *S.aspera* (wild) Benth and S.forbesii Benth are less significant economically (Haussman et al., 2000). Due to the 10,000–100,000 seeds per plant that can survive in the soil for up to 20 years, controlling striga has consequently become a very difficult task. This may result in annual seed shed rates of more than 1,000,000 seeds per square meter (Kroschel and Müller-Stöver, 2004). Once fields have been poisoned, this may cause the seed bank in the soil to rapidly accumulate (Wallace-Wells, 2019).

1.3. Significance of the study

Sorghum is a crucial food crop in Central America, South Asia, and Africa. Its scientific name is Sorghum bicolor (L.) Pers. It is the world's fifth-largest cereal crop after rice (*Oryza sativa* L.), wheat (*Triticum vulgare* L.), and maize (*Zea mays* L.). Barley (*Hordeum vulgare* L.). The estimated area covered by sorghum globally is a total of 99 nations in Africa, Asia, Oceania, and the Americas, covering around 44 million hectares. In Sub-Saharan Africa, sorghum is the second-most significant cereal crop after maize (Kumar *et al.*, 2021). About 300 million people rely on it as their primary source of food. Reside in the semi-arid tropical regions (Qader *et al.*, 2021). Sorghum is a versatile cereal that is traditionally used to produce a variety of foods, including kisra, injera, porridge, unleavened bread, biscuits, cakes, couscous, and malted beverages. Furthermore, grains play a significant role in the manufacturing of animal and poultry feed (1988, Doggett).

Due to the striga species' ability to parasitize new crops or types and adapt to changing environmental conditions, the problem caused by infestation is predicted to get worse. Striga, often notoriously known as witch weed, can completely destroy a crop's production (Ejeta, 2007). In Sub-Saharan Africa (SSA), it is believed that more than 60% of farmland under cultivation is infested with one or more striga species, which affects the production of approximately 300 million farmers in over 25 nations, resulting in losses of more than $7 billion (Ejeta, 2007). According to estimates, Striga alone caused an annual yield loss of $7 billion in sub-Saharan Africa, posing a serious danger to the way of life for more than 100 million people. People (Badu-Apraku and Akin wale, 2011). Striga is a serious issue in Ethiopia's northern and eastern cereal-growing regions (Fasil *et al.,* 2010). Repeated sorghum farming on the same field increases the striga population to the point where it is unprofitable to continue. Area and degree of infestation due to some countries' ongoing grain monoculture growth are projected to rise in the near future. Regions of Africa, which combined with severe moisture stress and decreasing soil fertility has resulted in the weed hence been characterized as a sign of inadequate soil fertility (Teka, 2014).

If the mechanism that could reduce the effect of striga weed on the growth and yield of *S. bicolor* were derived, farmers could benefit from it and improve the growth and yields of yellow sorghum, in addition to maximizing the yields of other crops that were seriously affected by striga weed. As a result, local farmers may be able to achieve food sustainability and reduce poverty. This study also serves as a benchmark for researchers who want to conduct further research in semi-arid, non-fertile areas around Mertulemariam town.

1.4 Basic research questions

1. Why do local farmers fail to control striga weed's impact on yellow sorghum's (Sorghum bicolor (L.?) Pers) development and yield?
2. What elements make striga weed more detrimental to yellow sorghum development and yield?
3. Could soil fertilization lessen the effect of striga weed on yellow sorghum growth and yield?
4. What are the best methods for controlling the way that striga weed affects the development and growth of crops?

1.5. The study's objectives

1.5.1. Overarching goal

The general objective of this study was to assess, investigate, estimate, and determine the effect of inorganic fertilizer applied on the infestation of striga hermonthica on the growth and yield of sorghum bicolor.

1.5.2 Particular goals

The specific goals of this study were to accomplish the following:

1. To investigate how applying various amounts of inorganic fertilizer affects yellow sorghum growth and yield in the face of striga.
2. Estimate the yields of yellow sorghum plants cultivated with varying amounts of inorganic fertilizer.
3. Determine the biomass of yellow sorghum plants grown with varying fertilizer application

concentrations.

4. To assess practical plans to lessen the impact of striga weed on yellow sorghum productivity.

1.6 Research Hypothesis

Ho: There is no discernible difference in the effects of varying fertilizer treatment concentrations on striga hermonthica infestation and sorghum bicolor growth and yield.

Ha: There are differences in the effects of varying fertilizer application concentrations on striga hermonthica infestation as well as on sorghum bicolor growth and production.

2. REVIEW OF LITERATURE

2.1Sorghum

Sorghum bicolor, sometimes referred to as sorghum, large millet, dura, jowari, or milo, is a type of grass cultivated for human use, according to the United States Department of Agriculture (Iyabo *et al*., 2018). The Latin word sorgo, which is now used to describe sorghum, signifies a cereal grass called *Sorghum bicolor* (*Sorghum vulgare*), which has broad leaves like maize and grain is carried by a tall, pithy stem at the end of a dense terminal cluster. Any economically significant genus of sorghum or an old-world tropical grass with a hairy rachis that resembles maize in habitat, notably any of the numerous cultivars evolved from a wild variety, like grain sorghum or sorgo. Synonyms for *S. vulgare*.

2.1.1 Morphology and taxonomy

Linnaeus originally described sorghum in 1753 under the name Holcus. Subsequently, Moench distinguished the genus Sorghum from Holcus and assigned it the binomial *Sorghum bicolor*.

The established sorghum genus and species taxonomic definition is consistent with the one in use today. From Moench. As a result, any information provided by different taxonomists is considered syn-*S.bicolor* (L.) Moench's aliases (McNeill and Turland, 2011).*S. bicolor* is a C4 annual or short-lived perennial grass family that has typically one generation per growing season. Within the grass family (Poaceae), the genus Sorghum belongs to the tribe Andropogoneae.

Sorghum comprises approximately 25 species and is divided into five sub-genera: Chaetosorghum, Hetrosorghum, Palasorghum, Stipsorghum, and Eusorghum (Venkateswaran *et al*., 2019). In addition to *S. bicolor*, the sub-genus Eusorghum contains the agronomically important species *Sorghum propinquum* (Kunch) and Sorghum halepense L. (peres), derived from past hybridizations between *S. bicolor* and *S. propinquum* (Paterson *et al*., 1995). *S. bicolor* is a diploid with 2n = 20 (Hodnett *et al*., 2019).

The considerable variability within the species, which is characterized as a complex with annual members of the sorghum family, has made the classification of *S. bicolor* contentious and difficult. There are 7 weedy, 13 wild, and 28 cultivated species in the subgenus Sorghum. Along with all of these species Later, the perennial members of *S. bicolor*, a single species, were placed together (Ananda *et al*., 2020). Three subspecies of *S. bicolor* are now recognized: bicolor, subspecies drummondii, and a subspecies of verticilliflorum. The domesticated species is a part of the subspecies bicolor. The grain is made from sorghum. Based on floral morphology, it is split into five interfertile races. (Bicolor, kefir, caudatum, and durandguinea), which has the capacity to develop 10 intermediate races (Muraya, 2014).

The wild type of *Sorghum bicolor* is included in the subspecies Verticilliflorum. Annual weedy derivatives resulting from domesticated sorghum hybridization and subspecies Verticilliflorum make up the subspecies Drummondii. The intergrades of subspecies Drummondii are highly variable due to gene segregation and include shatter cane (a feral form). And Sudan grass. Domesticated sorghum, Sudan grass, and sorghum crosses with Sudan. Other cultivated sorghums are also considered (Vigouroux *et al*., 2011).

2.1.2orgin, occurrence and geographic distribution

Bicolor originated in North Eastern Africa, where both cultivated and wild varieties still exhibit significant variation (Vigouroux *et al*., 2011). Archeological evidence from Sudan suggests that *S. bicolor* was domesticated between 8,500 and 4,000 years ago, during the early Holocene period. Over 3000 years ago, commerce and shipping routes likely allowed *S. bicolor* cultivation to spread from Ethiopia, where it is thought domestication took place, to Africa, the Middle East, and India (Dahlberg *et al*., 2011). Following that, cultivation spread from India to China along the Silk Road and to Southeast Asia as seed was transported via coastal trading lanes (Shewale and Pandit, 2011).

At the end of the 19th century, commercial cultivation of *S. bicolor* was brought to the United States from North Africa and India. Around 1950, *S. bicolor* cultivation in South Africa and Australia started to grow significantly (Koutika *et al*., 2022). Currently, *S. bicolor* is widely grown in Ethiopia and other dry regions of Africa, as well as in Asia, America, Europe, and Australia. Sorghum is grown between latitudes of 50 degrees north in North America and Russia and 40 degrees south in Argentina.

Due to the low production, there is little information available on the cultivation of *S. bicolor* in Canada (Drahun *et al*., 2022). Undertook field tests in the 1970s and 1980s to determine whether domesticated sorghum was suitable as a crop. *S. bicolor* is being researched as a food source. Especially in the south, grain output and use for bioenergy have expanded during the previous ten years. Quebec and Western Ontario (Antar *et al*., 2021). *S. bicolor* covers between 5,000 and 8,000 acres in eastern Canada. Are planted annually, and production and domestication plots have also been cultivated in Canada's western regions. *S. bicolor* is the fifth-most significant cereal crop in the world, following *Zea mays* L. (maize), Oryza species (rice), Triticum species (wheat), and *Hordeum vulgare* L. (barley). *S. bicolor* is widely grown and spread in more than 120 countries across Africa, Asia, Australia, and Europe in tropical, semi-tropical, and desert regions, as well as semi-arid regions (FAO, 2015).For the world's poorest and most food-secure population, *S. bicolor* is one of the key staple crops (FAO, 2011). As Ethiopia is the hub of origin and variety for Sorghum, the heritage of Bicolor has not changed because the crop has been grown for thousands of years. Done earlier (Birhanu Abegaz and Hailu Tessema, 2021).

2.1.3 Cultivation and crop use

Bicolor is cultivated for brooms, grain, fodder, sugar, bioenergy, and cover crops (Bakari *et al.*, 2023). 90% of domesticated sorghum in the United States is used for livestock feed, compared to 50% of domesticated sorghum utilized for human consumption worldwide (Taylor, 2019). *S. bicolor*'s capacity to go dormant during droughts and resume growth when conditions are favorable, as well as its tolerance to salinity and brief waterlogging, make it a desirable crop (Alsaeedi *et al*., 2022).

Under favorable conditions, bicolor can be double-cropped in semi-tropical climates (Verhulst *et al.*, 2010), and domesticated sorghum has yield potential comparable to rice, wheat, and maize (Soto-Gómez & Pérez, 2022). In Canada, interest in *S. bicolor* production is increasing, especially in south-western Ontario and Québec for use as bioenergy crops (Dwivedi, 2022). The potential use of *S. bicolor* for ethanol production is reviewed in Serna-Saldivar *et al*. (2012). Domestic use of *S. bicolor* in Canada is primarily animal feed in the poultry, beef, pork, and pet food industries. Domesticated sorghum can be grouped into flour and used in breakfast cereals, breads, pastries, beer, gluten-free products, and other food products (Woomer and Adedeji, 2021).

The dried, stripped panicles of *S. bicolor* are also used for making brooms, Canadian Food Inspection Agency (Johnson and Colla, 2023). The low value of important suggests that *S. bicolor* is not being imported for industrial processes. S.bicolor hybrids can be chosen based on yield potential, lodging, maturity, insect resistance, disease resistance, and cold tolerance (Madhusudhana and Aruna, 2022). Management practices are not well developed for *S. bicolor* in temperate climates, so more research is needed to adapt practices from other row and forage crops and optimize them for the Canadian environment (Delgado *et al.,* 2021). Agronomic practices vary based on the intended use and hybrids.

Harvesting the previous crop allows time for weed control, decay of crop residue, infiltration and storage of soil moisture, and fertilizer application (Adu *et al*., 2014).Land preparation practice includes shredding the stalks of the previous crop; disking, chiseling, rotary hoeing, plowing, or bedding the land; bed reshaping, and applying herbicides (Hartman, 2017). *Sorghum bicolor* can be grown in conventional or no-till systems. Most *S. bicolor* cropping systems involve crop rotation. Crop rotation can be used to improve weed control like striga weed, reduce disease and insect pressure, and enhance the physical characteristics of the crop (Storkey *et al*., 2019).

For ages, Gebisa bicolor has been one of the most significant staple foods for millions of underprivileged rural people in the semi-arid tropics of Asia and Africa (Chikssa, 2021). Sorghum continues to be a significant source of energy, protein, vitamins, and minerals in some underdeveloped areas of the world. Sorghum is fermented to make kisra in Sudan and injera flatbread in Ethiopia. Dosa is occasionally made with a sorghum grain blend in India (Ajagekar *et al.*, 2023). Similar to other staple foods like cassava that are widespread in underdeveloped areas of the world, sorghum grows in tough environments where other crops do not grow well. In many nations, it is typically farmed without the use of fertilizers or other inputs by a large number of small-holder farmers (Biramo, 2018).

2.1.4 Production trends

According to the Rather, the United States produced the most *S. bicolor* in 2023, with a harvest of 9.7 million tons. The following four largest *S. bicolor* producers, in descending order: India, Nigeria, Sudan, and Ethiopia all had sizable numbers. The other regions in the world that produce *S. bicolor* are Australia, Brazil, China, Burkina Faso, Argentina, Mali, and Burkina Faso. These regions had the largest harvests worldwide. Egypt, Niger, Tanzania, Uganda, and Cameroon. S.bicolor's top manufacturers, Nigeria (12.6%), India (11.2%), Mexico (16%), and the US (10.2%), were the top four countries in 2011, and the remaining 50%. *S. bicolor* flourishes in a variety of climates at high altitudes and on hazardous soils, and it may regenerate. Following some drought (Saha & Mazumdar, 2017). It is one of the most adaptive due to its five properties. Crops that can withstand drought, such as this one, have very extensive roots. The ratio of to-leave surface area during If a drought persists, in order to minimize water loss through transpiration, it spreads out its leaves. It utilizes C4 carbon during dormancy, which prevents its leaves from decaying and shields them with a waxy cuticle. Fixation, consuming only a fraction of the water needed by C3 plants. The young, flexible peduncle of *S. bicolor* with a hefty, curving peduncle will bend, which will lighten. Paired with awed inflorescence in this place, the shape of a two-told defense against the eating birds (FAO, 2012).

In the future, in Tanzania, sorghum output and consumption may rise if farmers shift from maize to drought-tolerant crops in regions where rainfall is decreasing as a result of climate change. Improved sorghum cultivars, according to Tanzanian farmers, grow more swiftly, require less labor, and are more resilient to disease and pests (Thomson, 2013). In 2010, 55.6 million tons of soybeans were harvested worldwide. For the 2010 sorghum harvest, the global average yearly production was 1.37 tons per hectare. Jordan has the highest yielding sorghum plantations, with an average annual production of 12.7 tons per hectare. In the USA, the world's largest producer, the average production per acre was 4.5 tons. The yields per hectare have been rising, while the amount of farmland dedicated to sorghum crops has been decreasing. With 77.6 million tons harvested, 1985 was the largest sorghum crop produced globally in the previous 40 years (FAO, 2011).

In terms of area covered, sorghum production in Ethiopia is ranked fourth, behind wheat (Triticum), teff (*Ergotis teff*), and maize (*Zea Mays*). Grown on 1,253,620 hectares, it makes up 14.2% and 13.6% of the crop area, with a total productivity of 1,715,940 tons (Penn, 2021). And thus, output. Consequently, the cultivation of sorghum is a major source of income for about 3, 674, and 865 farming households.

2.1.5 Reproduction mode

Sorghum bicolor is mostly self-pollinating, but under certain conditions, wind-mediated cross-pollination can reach up to 60%, depending on the genotype (Jhala *et al*., 2021). As a result of self-pollinating and outcrossing, according to Schlegel in 2017, the majority of sorghum land races cultivated by subsistence farmers are blends of partially and fully inbred lines. Outcrossing levels vary depending on the cultivar's panicle type; typically, outcrossing is higher in loosely panicled domestic sorghum and lower in compactly panicled sorghum. According to estimates made under field settings, the outcrossing rate of domesticated sorghum ranges from 5% to 40% (Begna, 2021). Several kinds of pollinators have been seen repeatedly stopping by domestic sorghum blossoms, up on bug collection. Pollen grains from sorghum and honey were discovered on all insects (Abhishek, 2021). It was unclear whether insect migration led to cross-pollination, though. More research is required to ascertain the degree of insect *S. bicolor* pollination. The flowering and pollination of *S. bicolor* are described in Abhishek (2021). Inflorescence development begins when a floral initial forms 30 to 40 days after germination. In warm regions, domesticated *S. bicolor* typically blossoms 55 to 70 days after germination. But based on the genetic makeup and environmental conditions, flowering may occur 30 to 100 days after germination. Wet and cool weather can also delay flowering. Flowering begins to open two days following the inflorescence's appearance from the boot. Flowering starts in the sessile spikelet (multiflowered sub divisions of the inflorescence) and begins from the stem's tip and moves downhill over the course of four to five days. Up to 6,000 florets can be seen in a single panicle (Yoon *et al.*, 2018). In a field, not every head flowers at the same time. Flowering time varies based on the genotype and climatic conditions, usually occurring from midnight to mid-morning and peaking around sunrise.

When the stigma becomes visible, the stamen filaments elongate, and the anther becomes pendant. When the anther dehisces, pollen is shed through the apical pore. Most pollen from a head fertilizes eggs on the same head. Cross-pollination can occur if the air is filled with blown pollen. The stigma is pollinated before the emergence of the anthers from the spikelet. Pollen grains drift to the stigma and germinate. The pollen tube develops has two nuclei and develops to fertilize the egg along the style. An egg is fertilized by a sperm nucleus to create a 2n embryo, then additional nuclei combine with the polar nuclei to create a 3n endosperm. After pollination, the glumes close, and the empty anthers and stigma usually protrude. Some long-glume varieties are cleistogamous (florets do not open fertilization). Pollinated stigmas remain receptive for up to 16 hours after fertilization. Organ differentiation occurs over approximately 12 days. Seeds pass through three developmental stages: milk, early dough, and late dough, and reach maturity after about 30 days. *S. bicolor* reproduces through seeds.

2.2 Striga hermonthica (Delile) Benth and its effect on crops

S. hermonthica is an obligate root parasite, it coordinates its growth with that of its host (Bouwmeester *et al.*, 2021). Because attachment of both germination and homorial commencement has to occur extremely close to the host plant roots, weed germination progresses in reaction to chemicals that the host plants release. Striga seeds undergo a dormant stage and are incapable of sprouting during the growing season. This is due to the post-ripening process, which stops freshly grown striga seeds from sprouting too late in the growing season.

Striga seeds yield more seeds per fully grown plant and can remain dormant in the soil for up to ten years (Dafaallah, 2019). Due to their small size, these seeds have a finite amount of energy. Because it must rely on its meager seed supplies, this condition will only allow a germinated striga to survive in a free-living form for a brief amount of time. Crop production losses due to striga infestations might vary based on striga seed density, soil fertility, rainfall patterns, and the type of cereal host species that are grown (David *et al*., 2022). In total, 25 African nations reported striga infections in 2005.

Striga affects more than 100 million individuals in Africa and costs the continent's economy about $1 billion USD annually (MUTHINI, 2023). Significant cereal crops that suffer catastrophic output losses are infected by striga, including maize, sorghum, and upland rice. Farmers have reported losses of 20% to 80%, and they are ultimately compelled to abandon heavily afflicted fields (Atera and Itch, 2011). Under severe drought conditions and high infestation levels, vulnerable cultivars can possibly experience 100% grain yield losses (Orimoloye, 2022).

Based on projections by Yali (2022), Striga infestations cover 17.2 million hectares, or 64%, of the overall West African sorghum crop area. Because of ongoing grain monoculture and low input rates for organic and mineral fertilizers, the infestation area and levels are predicted to grow in the future. In the sparsely productive semi-arid region of Africa, *Striga hermonthica* (Del.) Bentham and *S. Asiatic* (L.) Kunze are the primary biotic factors limiting crop productivity, but Aspera (Wild.) Bentham and *S. firebase* offer advantages of less significant economic value (Haussmann *et al.*, 2004). As a result, managing striga has grown to be a challenging chore given that each plant produces 10,000–100,000 seeds, each of which can survive in the soil for up to 10 years (Khan *et al.*, 2020). This may result in annual seed shed rates of more than 1,000 seeds per square meter (Fenner, 2012). When fields are contaminated, this may cause the seed bank to quickly accumulate in the soil (Fenner, 2017).

Numerous technologies have been used in striga control research for a long time. Have been created (Sibhatu, 2016). Struggles to control the striga problem have failed, yet it still exists. Despite a lengthy history of research on the parasitic weed, there are few approaches for control that have been adopted (Abbas *et al*., 2018).

2.2.1Description

Striga, sometimes known as witch weed, has small, appealing flowers with vibrant colors and brightly colored stems and foliage. They are obligate hemiparasites of roots that must have a living host for germination and early growth before being able to live independently. Although earlier classifications placed it in the Scrophulariaceae family, the genus is now assigned to the Orbanchaceae family (Fu *et al*., 2018).

2.2.2 Occurrence, distribution, and origin

Joel (2000) claims that striga plants (Orobanchaceae) are obligatory root parasites of cereal crops that disrupt photosynthesis, vie with other plants for resources, and create. They create a phototoxic impact within days after attaching themselves to their hosts (Weihs *et al.*, 2012). Despite being found in over 40 countries, striga are most commonly found in semi-arid tropical Africa (Silberg *et al*., 2021). Striga might have originated anywhere between Ethiopia's Semen Mountains and Sudan's Nubian Hills (Aruna *et al*., 2018). *Sorghum bicolor* (L.) Moench, a domesticated form of sorghum, was also developed in this area.

There are about 30 striga species known, and the majority parasitize grass species (Poacaea). The only striga species that is pathogenic to monocots is *Striga gesneroids* (wild) (Mohamed and Musselman, 2008). *S. hermonthica* is the most socioeconomically significant weed in Eastern Africa among the 23 striga species that are widespread throughout Africa (Degebasa *et al*., 2022). *Striga hermonthica* is most detrimental to cereal crops like sorghum, maize, and millet, but it's also spreading to rice and sugarcane fields (Atera and Itch, 2011). Crops that were previously striga weed-unaffected are now displaying signs of widespread infestation (Atera and Itch, 2011). Low soil fertility combined with drought-induced stress and susceptible host cropping predisposes the area to striga, and the parasite's enzyme system thrives in these conditions (Tesso *et al*., 2018). As a result of the removal of organic matter and the sparing use of compost, the majority of soils have lost their fertility.

2.2.3 Symptoms and Infections

Although the majority of striga species do not harm human agriculture, some species can have catastrophic effects on crops, especially those grown by subsistence farmers. The most frequently impacted crops are sugar cane, sorghum, rice, and maize (Atera and Itch, 2011). *Striga Asiatic*, *Striga gesneroids*, and *Striga hermonthica* are some of the species that cause the most harm. Witch weed has the potential to drastically reduce harvests and, in some cases, even completely destroy crops. Stunting, wilting, and chlorosis in the host plant were symptoms that were comparable to those associated with vascular disease, severe drought damage, and nutritional deficiencies (Icier *et al*., 2006).

2.2.4 Life span

In the presence of the root of the host plant, each striga plant's seed can produce a number of seeds, some of which may endure for nearly a decade in the soil (Icier et al., 2006). When host roots exude and produce historians that enter host root cells, striga seeds begin to germinate. Strigolactones, signaling chemicals that encourage striga seed germination, are present in host root exudates. A bell-shaped swelling develops where the parasitic roots are attached to the host plant's roots (Icier *et al*., 2006).

In an emergency when it quickly blooms and produces seeds, the pathogen may spend the following four to seven weeks underground developing. Witch weed Seeds spread readily in the wind, in water, and soil-borne animals. The primary method of dissemination involves human activity and mechanized tools.

2.3. Methods for controlling S. hermonthica

Both cultural and technological strategies are used to control striga. Numerous cultural methods have been suggested for striga, including crop rotation and intercropping (David *et al*., 2022). The yield is also decreased by hand weeding (Rather *et al*., 2023), water management (Chidiebere *et al*., 2015), and other methods. By using these methods, the amount of striga seeds that are now in soil seed banks should be decreased (Fasil and Verkleij, 2007). Some of the techniques increase soil fertility, promoting the growth of the host plant, but at the expense of the juvenile striga plant's germination, attachment, and subsequent attachment development (Fasil and Verkleij, 2007). For small farmers, this strategy has had mixed results, primarily because of socioeconomic and financial limitations.

2.3.1. Hand weeding and sanitation

Today, farmers still use manual weeding as their primary technique of weed control against striga. It is advised to stop seed germination and dissemination. Striga plant weeding is a laborious task that may not help to avoid striga on plants that are already contaminated; seed production must be stopped to prevent soil contamination. It is advised to hold off until two to three weeks after S. hermonthica blooms before starting to hand pluck striga due to the high cost associated with repeated hand pulling. This will help prevent seeding (Lee and Thierfelder, 2017). To stop the parasite from continuing to grow and seed, crop stubble should also be uprooted or so, resulting in decreased crop growth and generally lower yields (Walia and Walia, 2021). Hand weeding dense infestations is impractical, and weeding is frequently inefficient, especially because it is labor-intensive and time-consuming (Parker and Riches, 1993). At a basic level, it is useful. Infestation combined with fertilizers or pesticides, occurring before striga flowering.

2.3.2. Crop rotation

The simplest approach is, in theory, to rotate the crops on diseased soil with non-susceptible crops or to practice fallowing. Rotation with non-host crops reduces the number of striga seeds in the soil by stopping new seed formation. This technique's practical restriction is that rotation takes longer than three years. As a result, the rotation crop selection process should prioritize sustainability in the given environment, followed by potential for use as a trap crop (Jourdian *et al*., 2020).

Ethiopian possibilities include switching over infected regions of maize or sorghum to groundnuts, wheat, or pulses. According to reports, striga infestation in Ethiopia was reduced by 50% after farming for two years to a non-host (Yali, 2022). According to the findings of a four-year trial in bush fields, one season of cow pea in 1998 appeared to have a good impact on succeeding millet grain production. Reduced striga infestation, as well as higher amounts of soil organic carbon and nitrogen. When compared to continuous millet planting for three to five years, the production increases brought about by millet-cow pea rotation were 37% in 1999 (Bado *et al.*, 2022).. However, it could be challenging to convince small-holder farmers to produce other crops if they want to optimize the grain production potential of the area. Utilizing a schedule of crop rotation, weeding sanitation, and resistant cultivars together yields practical control techniques that are effective.

2.3.3. Trap and catheter crops

Due to the weed's suicidal germination caused by trap crops, the amount of seeds in the soil is reduced. Some cowpea, groundnut, and soybean types may lead to suicidal thoughts. Germination and increased fertility of soil (Hafez *et al*., 2021). The striga, while intercropping various legumes with maize and sorghum, reduces striga and germinates suicidally when trap crops like soybeans are used. The striga is removed before the seedlings that do not attack the soybean. Akanbelum *et al.* (2023) found that when soya beans are intercropped with maize, they cause suicidal germination of striga and decrease the striga soil seed bank in the soil. This diminishes the seed density of striga in the soil and prevents it from flowering there (Sibhatu, 2016).

Catch crops are sown to encourage a large proportion of parasite seeds to sprout, but they are removed from the ground or harvested before the parasite may procreate. Six to eight weeks before striga produces seeds, a dense planting of Sudan grass should be made at a rate of 20 to 25 kg seed per hectare and either ploughed in or gathered for feed. The primary rain might then be used to plant the major crop (Parker and Riches, 1993). From the available studies, it can be concluded that trap crops should be cultivated for at least three consecutive years in order to reduce the parasite seeds (Sharma *et al.*, 2019). Pasture legumes (*Muana gigantic*, *Stylosanthes*, *Guyanensis*, and *Desmodium*) species were investigated for their ability to induce germination of striga hermonthica seeds and for their effect on striga attachment and on striga shoot emergence. Laboratory experiments showed that the root exudates of the legumes stimulated up to 70% more striga seeds to germinate than the exudates of maize.

2.3.4 Intercropping

In the majority of Africa, It's common practice to intercrop cereals with legumes and other crops. Intercropping has been reported to have an impact on striga infestation in Africa and is a potentially practical, low-cost method (Begna, 2021). Intercropping is a feasible and cost-effective method for tackling poor striga and soil fertility, two important and related issues (Shanka, 2020).

Sorghum grown in conjunction with cow pea and preliminary testing in Ethiopia showed that haricot bean was effective against striga and produced a noticeably better yield per unit area. It has been demonstrated that intercropping maize with cowpea and sweat potatoes considerably lowers the appearance of striga in Kenya (Kirimi, 2019). In Kenya more recently, it was discovered that inhibition of striga was significantly greater in maize silver-kaf [*Disodium uncinatum* (Jacq.) DC] intercrop than that observed with other legumes, for example sun hemp (Crotalaria species), soya bean or cow pea (Khan *et al.*, 2007). Consequently, the yield of maize was significantly increased by two tons per hectare.

Disodium species are legumes that can be easily controlled by regular cutting in order to avoid or minimize the crop's potential. It was discovered that Uncinatum inhibits the growth of haostorial striga by an allelopathic effect, which lowers striga infestation in intercropping (Khan et al., 2001). Finding the substances secreted by *D. uncinatum* that are responsible for the parasite's suppression could lead to greater opportunities for the development of dependable intercropping plans and novel techniques for *S. hermonthica* molecular biology (Kopper and Ruelle, 2022).

It does not completely eradicate the weed (Khan, 2007). This explains why Striga infestation is still high in most fields, even though most farmers in western Kenya intercrop cereals and legumes as their main cropping strategy. In order to effectively control striga, a different intercropping technique is known as "push-pull," in which Desmodium species are intercropped with cereals with an age of fodder crops. In order to increase the effectiveness of current control systems, it is necessary to combine many strategies (Bedford, 2015).

2.3.5 Soil fertility

The degree of striga damage to the hosts increases with water stress, nutrient shortages, and a lack of nitrogen and phosphate. Striga is highly harmful to low-fertility soil, and when nitrogen and phosphorus are provided in insufficient amounts, the infestation typically diminishes (Sakadzo *et al.,* 2021). Because it is a part of chlorophyll, nitrogen encourages vegetative development and green foliage (Fathi, 2022). Therefore, without nitrogen, plants are unable to complete their life cycle, including germination, growth and development, flowering, and the creation of seeds that would restart the life cycle of the plant (Miryeganeh, 2021).

Phosphorus is one of the essential minerals required for plant growth and development. Photosynthesis, respiration, energy storage, cell division, and maturation are all significantly impacted by it. Additionally, it contributes to the synthesis of a variety of biologically active compounds (Li petri, 2021). Phosphorus is a vital component of plant development and seed production and plays a significant part in the life cycle of plants (Mousavi, 2021). Application of fertilizer had a sizable impact on height. Sorghum reaction score, shoot count, dry matter output, days until emergence, and striga's dry weight all indicate that high nitrogen fertilizer applications improve the performance of cereal crops when striga is present.

Another important element that plants obtain from the soil is potassium, which is essential for plant metabolism, chlorophyll formation, protein synthesis, and other vital plant functions. Weak stems and roots, areas of dead tissue, and yellowing are all signs of plants deficient in potassium (Abbas, 2021).

According to the results of an experiment to develop an integrated nutrient management strategy (Wu, 2020), the combined use of compost could significantly reduce infestation and significantly increase sorghum yield. The experiment also discovered that increasing soil fertility not only promotes the growth of the host but also negatively impacts the striga seeds' longevity in the soil, germination, and attachment, as has been noted in western countries that host plants. Application of high nitrogen-low fertilizer dosages is typically helpful in postponing the striga emergency and achieving higher crop development (Badu-Apraku, 2023).

2.3.6 Push-pull technology

The intercropping technique known as "push pull" uses fodder legumes as well (Rahman, 2021). Mishra *et al.* (2022) describe how controlling beneficial insects and their distribution and abundance aid in the management of pests by using behavior-modifying cues. Originally designed to combat stem borers, this technology has since been discovered depending on whether the intercropping component was utilized with the main crop to additionally prevent striga weed in the field.

Pests are driven diverted from the intended crop by factors that give hosts an appearance in the push-pull technique. The target crop is protected as, in tandem, the pests are dragged (pulled) to a concentrated area within a trap crop. Disodium is incredibly successful at preventing striga (Ghirardelli, 2023), which increases maize yields by 3.5 tons per hectare per cropping season while also increasing agricultural productivity. In addition to the benefits derived from the increased availability of nitrogen. The drastic decrease in striga infestation is caused by an allelopathic impact of Disodium root exudates (Pakdaman *et al*., 2018). Secondary metabolites with striga seed germination stimulatory and host germination inhibitory substances are present in the root exudate of *D. uncinatum*, which directly interferes with parasitism (Vuro *et al*., 2019). Thus, even in the presence of neighboring cereal hosts, this combination offers an innovative way to reduce the striga seed bank in-situ through effective suicidal germination (Yilma and Bekele, 2021).

2.4 The growth performance and yield of *S. bicolor* in nursery beds as a result of inorganic fertilization

Fertilizer is added to the soil to aid in plant growth and increased yield. With the discovery of the chemical needs of developing plants by ancient farmers, fertilizer technology evolved significantly. Plants are made up of cells, much like all other living things. Between these various chemical processes are responsible for development and reproduction throughout the course of a cell's metabolism. Plants rely on nutrients in the soil because they do not consume food like animals do. Give these metabolic reactions the fundamental molecules they need. The availability of certain parts in soil is finite, and when Plant quality and output decline when plants are harvested because of this (Gomiero, 2016).

Fertilizers replenish the chemical elements that plants take from the soil. Nonetheless, the purpose of fertilizers is also to boost the soil's growth potential. Compared to organic soil, it can create a more conducive growing environment. They can also be adjusted to match the crop type being produced. Compounds containing potassium, phosphorus, and nitrogen are also commonly found in fertilizers. They also include trace elements, which aid in the more efficient development of plants. The use of organic compost and artificial fertilizers has both beneficial and detrimental effects on soil development and vegetation. By supplying more plant nutrients, fertilizers influence plant development, which enables plants to grow thicker and faster. This only applies, though, if the soil is weak in nutrients.

Other growth-inhibiting elements, including a lack of water, inadequate soil preparation, and weeds, are not made up for by fertilizers (Gomiero, 2016). Incorporating both inorganic and organic fertilizers into the soil has many advantages for enhancing its physical and chemical status, which boosts crop yield (Bhatt *et al*., 2019). Fertilizers help plants develop more quickly. This objective is achieved in two ways, the conventional one being nutrient-rich additions. The second way that fertilizers work is by enhancing the soil's capacity to hold onto water and breathe.

2.4.1Effects of inorganic fertilizer on growth performance and yield of *S. bicolor*

In Ethiopia, Striga is responsible for 25% of the yearly losses in sorghum (AATF, 2011). Fertilizer treatment insufficiently restricts sorghum yield by increasing S. hermonthica infection in addition to stunting growth and development. Consequently, it has been demonstrated that applying fertilizer can inhibit S. hermonthica infection while enhancing the host's growth and productivity (David *et al*., 2022).

Striga germination is facilitated by strigol, a sorghum root exudate that is used more frequently when large amounts of nitrogen are applied. In addition to providing the host with effective defense against the parasite, nitrogen boosts the affected crop's productivity (Mwangangi *et al*., 2021). Despite this, the smaller osmotic pressure gradient of the parasite and the higher nitrogen concentration of the host will prevent Striga from surviving if it germinates (Fernández-Aparicio, 2020).

The rate at which soil fertility declines is further accelerated when fertilizers, especially organic fertilizers, are either not used at all or used at levels below ideal. This creates the perfect environment for Striga weed growth. Fertilizer treatments will inevitably alter the qualities of the soil, either in a favorable or negative way. The ability of the soil to react to additional fertilizers is influenced by various soil qualities, which in turn affect the total crop production (Pahlavi, 2021).

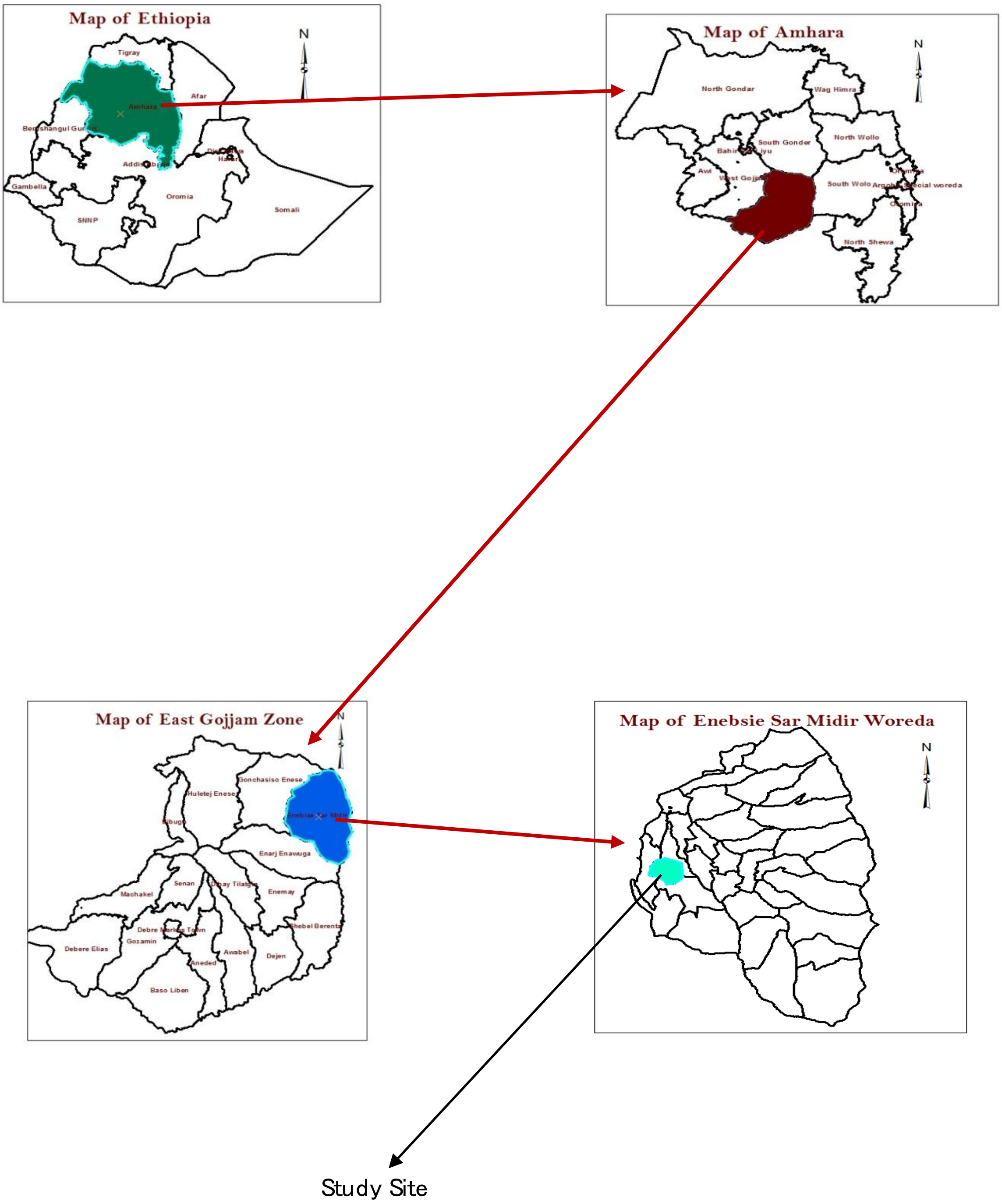
Despite the fact that numerous methods have been used to lessen the impact of striga weed on agricultural yields, it nevertheless flourishes significantly in the poor fertility soils that are typical in the research area. Since farmers can afford tiny quantities of inorganic fertilizers, which can then be blended with readily accessible organic fertilizers, the combined application of organic and mineral fertilizers is a practical technique. This is anticipated to improve the physical, chemical, and biological characteristics of the soil, thus improving fertility overall. Enhance crop growth favorably while decreasing Striga infestation with better soil fertility. Striga incidence is said to decrease as soil fertility is increased. This might result in higher soybean yields, better food security, and greater social welfare. Consequently, it is possible to efficiently boost the sorghum yield by adjusting the amount of organic and nitrogen fertilizer applied to the soil.

3. MATERIALS AND METHOD

3.1An explanation of the research field

The current study was carried out in the town of Mertulemariam in December 2023 and June 2024. Mertulemariam is situated in the East Gojjam Administrative Zone of the Amhara Regional State of Ethiopia, in the countries northwest. Mertulemariam is located 180 km from Bahir Dar. The experimental site is located at the latitudes 10° 45N and 11° 1N and longitudes 38° 14E and 38 It serves as Enbsie Wereda's administrative hub. The total area of the Wereda is 106,533.63 hectares and has a population of 146,192, of which 72,223 are males and 73,969 are females in 2014 (information obtained from the Enbsie Wereda finance office). Enbsie Wereda is composed of 35 K*ebeles* that have three agro-ecological zones, namely kola (57.86%), woynadega (37.14%), and dega (14%). (Information obtained from Enbsie Wereda agricultural office.) The study area's height varies from 950 m to 3660 m above sea level; the annual temperature and rainfall ranges fall between 26-30 and 600-900 mm, respectively.

From the total area of the Wereda, 98,460.52 hectares of farm land were covered by the common cereal crops such as yellow sorghum [*Sorghum bicolor* (L.) Pers], maize *(Zea Mays*), navy bean (*Phaseolus vulgaris*), teff (*Eragrotis teff),* pea *(Pisum Sativum)* and wheat *(Triticum*) (information obtained from the Enebsie Wereda agricultural office).



Source:-Enebsie Sar Midir Woreda Land Use Office

Figure 1: Map showing location of the present study area Mertulemariam town, East Gojjam Administrative Zone**.**

3.2 Field observation

Field observation was one of the data collection methods that helped to collect data by observing and recording the real events about yellow sorghum. I observed the effect of striga weed on yellow sorghum land race and the soil type that was suitable for the spread and growth of striga weed and finally what would be the final effect effects striga weed on yellow sorghum's early development characteristics.

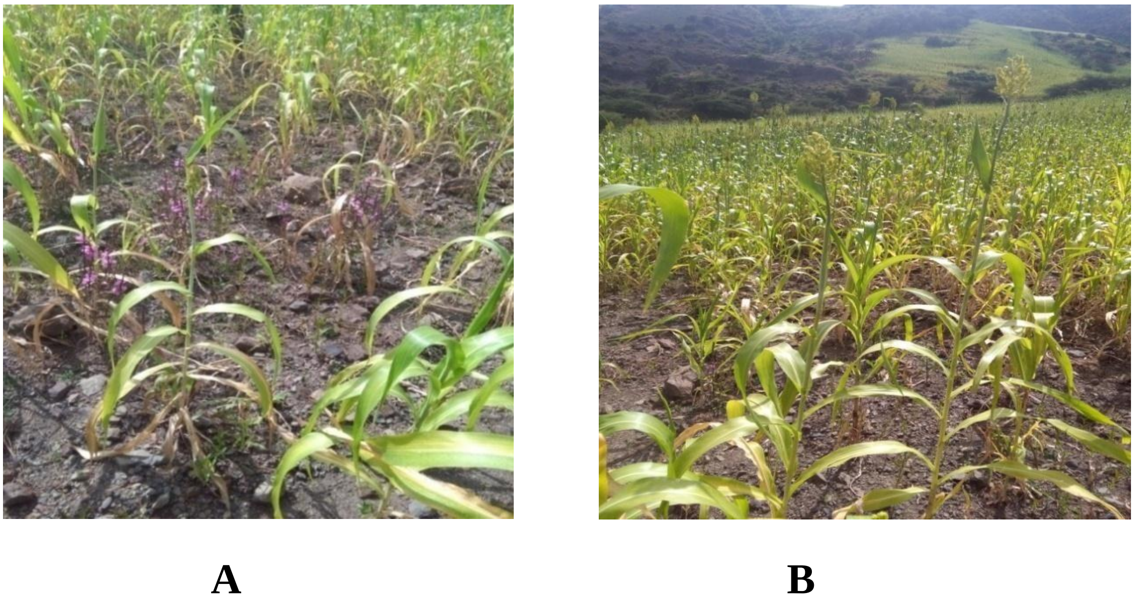


Figure 2:(A)Yellow sorghum farm infested with striga in Anesa *Kebele*; (B) Similarly yellow Sorghum farm in Wasma *Kebele*, East Gojjam Administrative Zone**.**

3.3 Setting up a nursery bed

Prior to beginning the actual plastic bag experiment, a nursery bed that was 120 cm by the prepared 300 cm was large enough to hold the 24 plastic bags. The golden sorghum plants in the nursery were shielded from the wind and household animals by a wooden fence. To keep the bags wet and keep birds and certain flying insects out of the nursery bed, insecticide net stalks were used to cover them.

3.4 Seed preparation

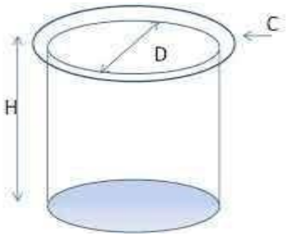
Seeds of yellow sorghum were obtained from Anesa Kebele during December 2023. After the seeds were cleaned using a sieve to eliminate any debris, they were kept in paper bags at room temperature until needed.

Figure 3 Bachete sorghum variety (left) Wagere sorghum variety (right)

3.5 Analyzing and sampling soil

Samples of soil were taken from the non-fertile semi-arid area around Mertulemariam town, particularly from Anesa Kebele. Striga infected soils and sand thoroughly mixed in the ratio of 3:1. Striga-infected arenosols were taken from farmland where previously striga weeds were grown. Next, in order to guarantee as much uniformity in the sample as possible, non-fertile arenosols were dried in the sun and then ground into a huge composite soil sample.

24 cylindrical plastic bags were bought from the local market of Mertulemariam town on October 4, 2023, and employed in the current investigation (depth: 28 cm, diameter: 18 cm). Areas of each plastic bag could be calculated before starting the actual experiment.



$$A = \pi r^2$$

$$A = \pi r^2$$

$$A = \pi r^2 H$$

Where A is the area of the cylinder, ∏=3.14, where H is the cylinder's height and r is its radius

$A=3.14\times0.09m\times0.09m\times0.28m$

$A=0.014m^2$ Area of each plastic bag.

3.6 Inorganic fertilizer calculation

The inorganic sources of nitrogen, phosphorous and potassium were artificial fertilizers (DAP and urea). According to ANRSBA, 100kg DAP per hectare is recommended for crops like maize, sorghum and other related species that grown in arid and semi-arid areas. The mount and application of fertilizer could be calculated as follows.

1hectare=10,000m2=100kg DAP

$0.014m^2=?$

0.0014kg=14gram of DAP required for each plastic bag

3.7 Planting seeds of *Sorghum bicolor two varieties Bachete and wagere* and planting technique under conditions similar to nursery beds

24 plastic bags with a 28-centimeter depth and an 18-centimeter width were filled with 1 kg of

non-fertile soil measured with the aid of an IS-8 made in India model. Two varieties of Sorghum bicolor Bachete and wagere stratified with different ratings of fertilizer 0, 25, 50, and 100% inorganic fertilizer. Under RCBD, the treatments were organized into three replications. Improved sorghum variety Wagere adapted to the area was used. The treatments (T) were (T1). no fertilizer + striga + Bachete variety as control (T2) 25% fertilizer+striga+Bachete variety (T3) 50% fertilizer+striga+Bachete variety (T4) 100% fertilizer+striga+Bachete variety (T5) no fertilizer+striga+Wagere variety as control (T6) 25% fertilizer+striga+Wagere variety (T7) 50% fertilizer+striga+Wagere variety (T8) 100% fertilizer+striga+Wagere variety.

Growth parameters were plant height, leaf number, internodal length, and leaf area, number of tiller, root collar diameter, seed number, seed weight, panicle size and biomass were determined. On the ready nursery bed, the bags were labeled and placed at random. Plastic bag placement is done at random using lottery-style techniques.

On June 20, 2015, 120 seeds were manually planted in plastic bag sand with the goal of finishing the planting process in one day. To make sure the soil had adequate moisture for the seeds, it was watered before the seeds were planted. In the center of each of the 24 wet bags, five large, healthy-looking yellow sorghum seeds were planted at a depth of 3 cm. This is because optimal germination results from planting at the proper depth. The seeds were deeply buried in the ground shortly after they were planted. The planted seeds in each bag were given the same quantity of pure water (130 ml) to water daily, and they were left to grow for five months in nursery bed conditions (mean minimum temperature during the study period was 27 <0x7E> 29 <0x7E> noon, and maximum temperature was 24 <0x7E> 26.5 <0x7E>).

Figure 4 :Sowing of seeds

A half dose of nitrogen in the form of urea was applied during planting, while the remaining 50% urea was applied at knee height. A full dose of phosphorus was applied as a band application method when planting, in the form of diammonium phosphate (DAP).

Figure 5 Fertilizers were added into the soil (A) Seeds were germinated (B)

Data on plant height (cm), panicle length (cm), dry biomass yield (g), grain yield (g), and days to 90% maturity were gathered from agronomic sources. The SAS software computer package version 9.0 (SAS Institute, 2002) was used to perform an analysis of variance (ANOVA) on the gathered agronomic data. The least significant difference (LSD) at the 5% probability level was used to calculate the significance difference among the treatment means.

3.8 Calculating field capacity of the soil

1. Striga infected soil and sand with a ratio of 3:1 thoroughly mixed.

2.1000 g of plastic potted soil in the jar filled with water for up to 6 hours; the mixture was fully saturated with water after 6 hours, then kept in the shade area to remove excess water through gravitational forces.

3. The potted plastic soil was placed on an open area for 2 days and weighed to be 1130 g.
4. The difference in weight (130 g) is the amount of water lost due to evaporation.
5. The amount of water watering every day for each plastic bag is 130 ml to retain the field capacity of water.

3.9 Data collection and statistical analysis

In the current study, key growth characteristics included plant height, intermodal length, and leaf count per plant, leaf surface area, and root collar diameter. Likewise, the quantity of seeds produced per plant, the weight of those seeds, the dry weight of the chaff, and the total dry weight were all taken into account as yield metrics. Measure height (in centimeters) increments from the base to the tip of the apex every 15 days till anthesis in order to compare the growth responses of seedlings grown in nursery beds. Similarly, leaf surface area (mm2) and leaf count were measured periodically at 15, 30, 45,60,75,90,105,120,135 and160days, respectively after germination. At harvest, the following weights were noted: total dry weight (g), chaff dry weight (g), and seed weight (g). Since the shape of leaves varies, it is not possible to calculate their area directly using mathematical formulas. Instead, one leaf from each plant sample was spread out over millimeter graph paper at uniform intervals of 1 mm, and the leaf's outline was drawn while the leaf was still attached to the plant. The total number of squares can then be obtained by adding the number of grid squares (both full and square) that are contained within the leaf. Area S2 was used to compute the leaf's estimated areas.

The means of the plant parameter data were calculated after analysis. When there were significant variations between the mean values reported in the appendices, the homogeneity subsets were determined using the analysis of variance (ANOVA) single factor for the germination, growth, and yield parameters of the study ($p < 0.05$).

(A)

(B)

Figure 6 Measuring growth parameters (A) 30 days old Bachete and Wagere varieties (B)

Figure 7:75 days old sorghum varieties of Bachete and Wagere

4. RESULT

4.1Growth parameters of yellow sorghum varieties Bachete and Wagere with striga grown at different concentrations of inorganic fertilizer in nursery bed.

4.1.1plant height

The mean height of seedlings grown in Bachete + striga + with no fertilizer, 25, 50, and 100% of inorganic fertilizer were 75, 90, 100, and 106 cm, respectively. Similarly, the corresponding mean heights for plants grown in Wagere+striga with no inorganic fertilizer, 25, 50, and 100% were 85, 95, 105, and 110 cm, respectively. Therefore, the mean height showed significant differences ($p\leq 0.05$) between seedlings of sorghum varieties Bachete and Wagere with striga grown in different concentrations of inorganic fertilizers that are 0, 25, 50, and 100%.

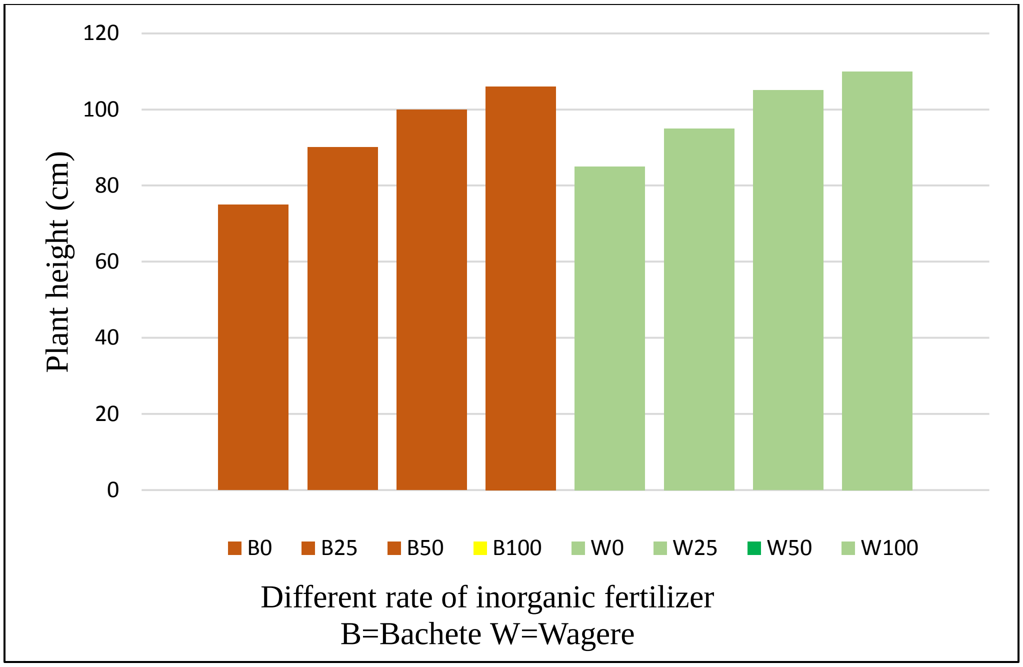


Figure 8 **:**Mean height (cm) of yellow sorghum varieties Bachete (B) and Wagere (W) with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer**.**

4.1.2Internodal Length (IL)

The mean height of seedlings grown in Bachete + striga + with no fertilizer, 25, 50, and 100% of inorganic fertilizer were 75, 90, 100, and 106 cm, respectively. Similarly, the corresponding mean heights for plants grown in Wagere+striga with no inorganic fertilizer, 25, 50, and 100% were 85, 95, 105, and 110 cm, respectively. Therefore, the mean height showed significant differences ($p \leq 0.05$) between seedlings of sorghum varieties Bachete and Wagere with striga grown in different concentrations of inorganic fertilizers that are 0, 25, 50, and 100%.

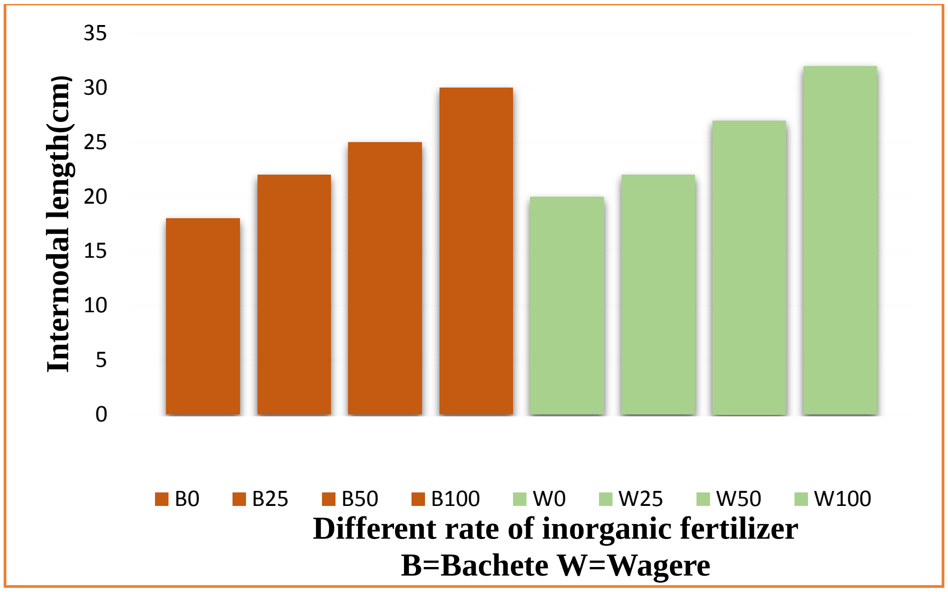


Figure 9: Mean internodal length of yellow sorghum varieties Bachete (B) and Wagere (W) with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer.

4.1.3Leaf number (LN)

The mean leaf number were 11 for plants grown in seedlings of sorghum varieties Bachete and Wagere with striga at different concentrations of 25,50 and 100%inorganic fertilizer grown over the control (8) on the 10thweek.

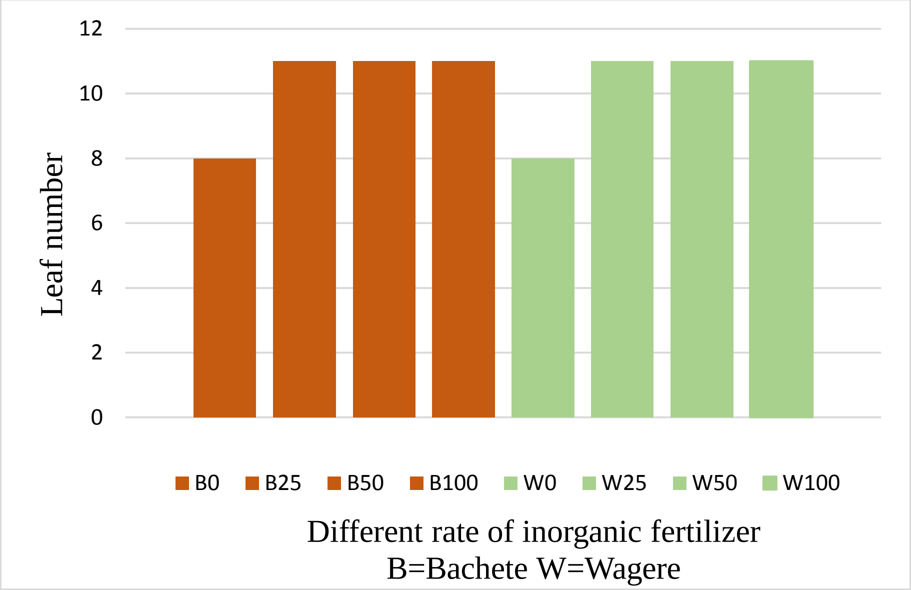


Figure 10: Mean leaf number of yellow sorghum varieties Bachete (B) and Wagere (W) with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer.

4.1.4Leaf Area (LA)

The leaf area of seedlings of sorghum variety Bachete with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer grown were 259.25, 270, 283, and 293 mm2, respectively. Similarly, seedlings of the sorghum variety Wagere with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer grown were 264.5, 276.5, 293.5, and 304.5 mm2, respectively. The leaf area of seedlings of the sorghum variety Bachete with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown was higher than the control. The leaf area of seedlings of the sorghum variety Wagere with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown had a higher leaf area than the control. Seedlings grown in the Wagere variety of sorghum showed a higher leaf area compared to those in Bachete with striga at an equal concentration of inorganic fertilizer applied, as shown in the figure.

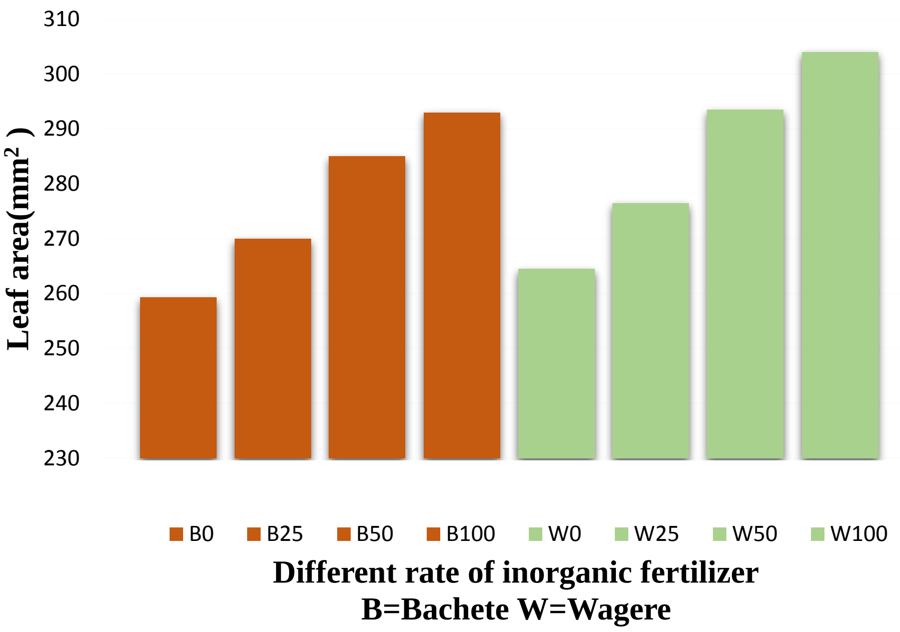


Figure 11: Mean leaf area of yellow sorghum varieties Bachete (B) and Wagere (W) with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer.

4.1.5Root collar diameter (RCD)

The root collar diameter at (p≤ 0.05) seedlings of sorghum variety Bachete with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer grown were 2.1, 2.4, 2.6, and 3.5 cm, respectively .Similarly, seedlings of the sorghum variety Wagere with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer were 2.3, 3.4, 3.5, and 3.7 cm, respectively. The RCD of seedlings of the sorghum variety Bachete with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown result obtained were higher than the control. The RCD of seedlings of the sorghum variety Wagere with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown result obtained were higher than the control. Seedlings of the sorghum variety Wagere showed higher RCD compared to those in Bachete with striga at an equal concentration of inorganic fertilizer applied, as shown.

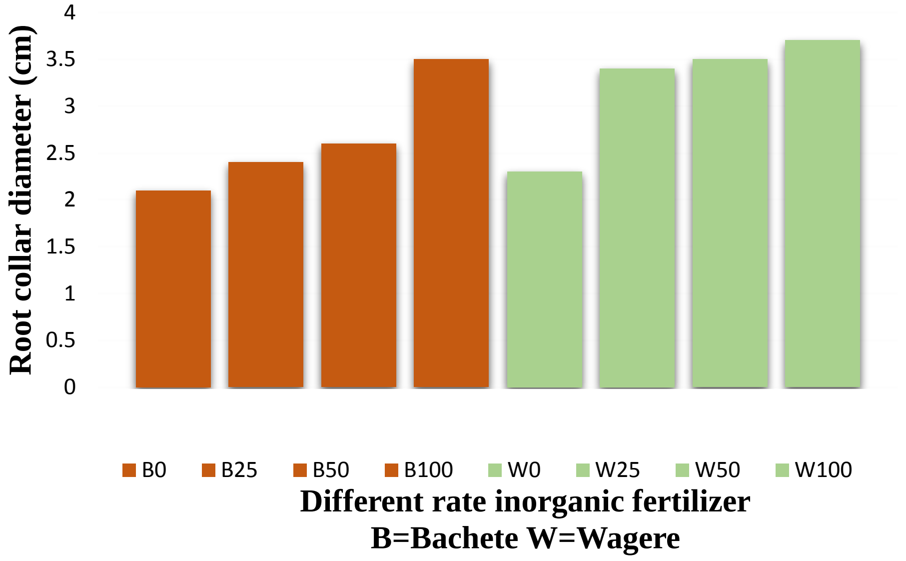


Figure 12: The root collar diameter of yellow sorghum varieties Bachete (B) and Wagere (W) with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer.

4.1.6Pancle size

The panicle size at (p ≤0.05) seedlings of sorghum variety Bachete with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer grown were 30, 40, 50, and 60 cm, respectively. Similarly, seedlings of the sorghum variety Wagere with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer were 35, 45, 55, and 70 cm, respectively. The panicle size of seedlings of the sorghum variety Bachete with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown result obtained were higher than the control. The panicle size of seedlings of sorghum variety Wagere with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown result obtained were higher than the control. Seedlings of the sorghum variety Wagere showed higher panicle size compared to those in Bachete with striga at an equal concentration of inorganic fertilizer applied as shown.

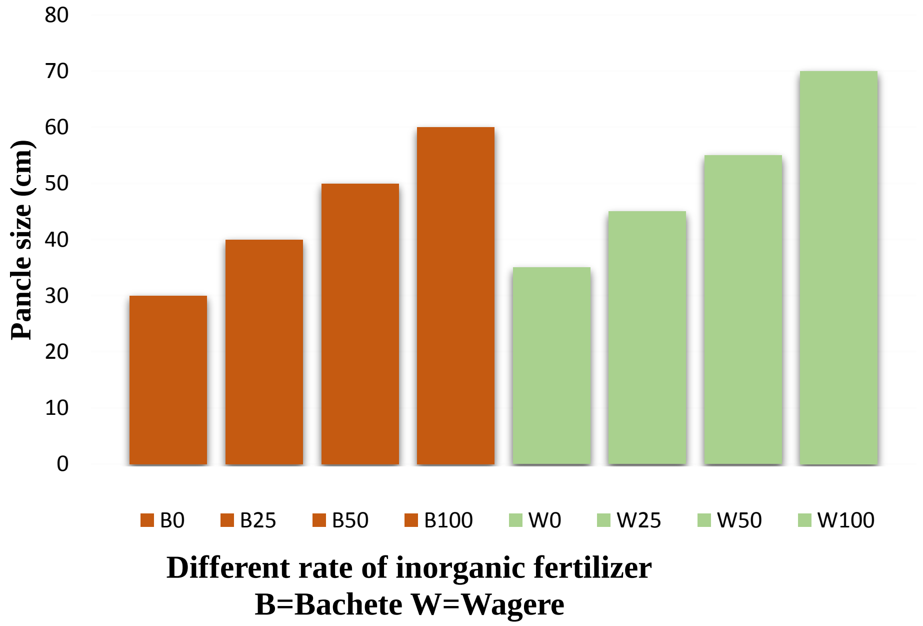


Figure 13: The panicle size of yellow sorghum varieties Bachete (B) and Wagere (W) with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer.

4.2Yield parameters of yellow sorghum varieties Bachete and Wagere with striga grown at different concentrations of inorganic fertilizer under nursery bed conditions

4.2.1Number of seeds per plant

The number of seeds per plant had significantly ($p \leq 0.05$) seedlings of sorghum variety Bachete with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer grown were 1950, 3430, 3500, and 3540 seeds per plant, respectively. Similarly, the quantity of seeds produced by each plant seedling of the sorghum variety Wagere with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer grown were 2000, 3590, 3630, and 3680 seeds per plant, respectively. The number of seeds each plant produces seedlings of the sorghum variety Bachete with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown result obtained were higher than the control. The number of seeds per plant of seedlings of sorghum variety Wagere with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown result obtained were higher than the control. Seedlings of the sorghum variety Wagere showed a higher quantity of seeds per plant as opposed to the number in Bachete with striga at an equal concentration of inorganic fertilizer applied, as shown.

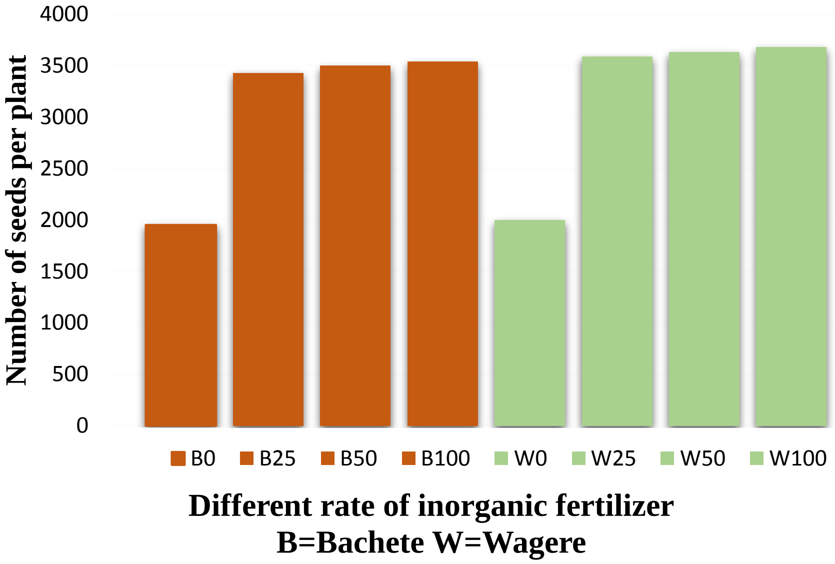


Figure 14: Number of seeds per plant of yellow sorghum varieties Bachete (B) and Wagere (W) with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer

4.2.2 Weight of seeds per plant

The average weight of seeds had significantly (p 0.05) seedlings of sorghum variety Bachete with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer grown were 95, 126, 128 and 129.8 g, respectively. Similarly, mean seed weight seedlings of the sorghum variety Wagere with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer grown were 100, 130, 132.2, and 132.6 g, respectively. The mean seed weight per plant of seedlings of sorghum variety Bachete with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown result obtained were higher than the control. The mean seed weight per plant of seedlings of sorghum variety Wagere with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown result obtained were higher than the control. Seedlings of the sorghum variety Wagere showed a higher mean seed weight per plant compared to those in Bachete with striga at an equal concentration of inorganic fertilizer applied, as shown.

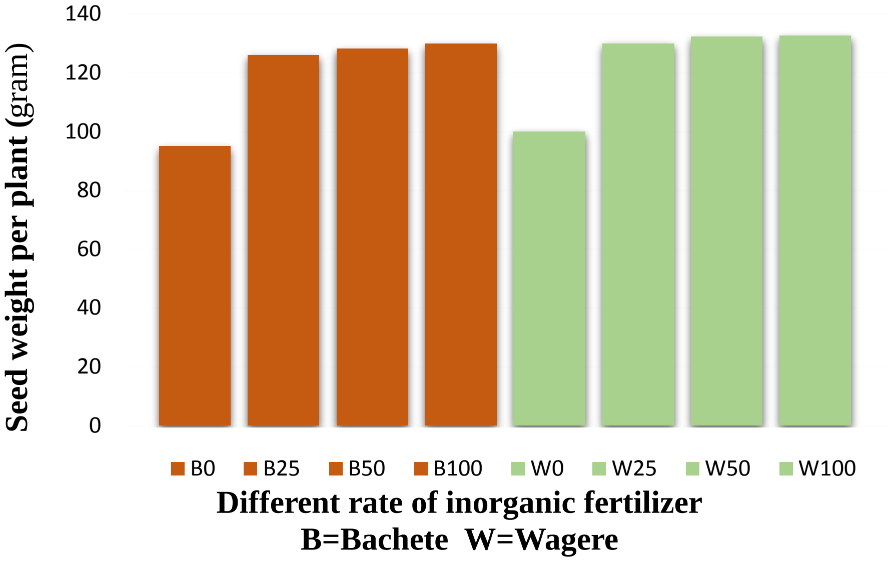


Figure 15: Seed weight per plant of yellow sorghum varieties Bachete (B) and Wagere (W) with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer

4.2.3Thousand seeds weight

From the sampled plants of each treatment, thousands of seeds were randomly selected and weighed in the digital balance SF-400 model to determine the seed weight from each treatment. Mean thousand seed weight had significantly ($p \leq 0.05$) seedlings of sorghum variety Bachete with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer grown were 35.5, 39, 39.4, and 41.8 g, respectively. Similarly, mean thousand seeds weight seedlings of sorghum variety Wagere with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer grown were 36, 41.8, 43.7 and 44.8g respectively. . The mean thousand seed weight seedlings of sorghum variety Bachete with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown result obtained were higher than the control. The mean seed weight per plant of seedlings of sorghum variety Wagere with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown result obtained were higher than the control. Seedlings of the sorghum variety Wagere showed a higher mean thousand seed weight per compared to those in Bachete with striga at an equal concentration of inorganic fertilizer applied, as shown.

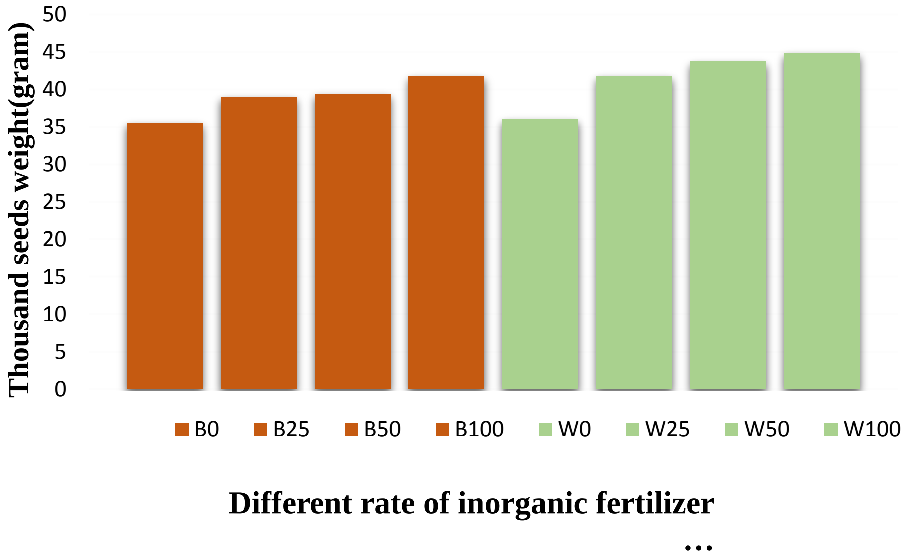


Figure 16: Thousand seeds weight yellow sorghum varieties Bachete (B) and Wagere (W) with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer

4.2.4Biomass production

There was a noteworthy distinction at p≤ 0.05. Biomass production seedlings of sorghum variety Bachete with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer grown result were 44.5, 50.7,52 and 54.4g respectively. Biomass production seedlings of sorghum variety Wagere with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer grown resulted in 47, 53.8, 54.9, and 57.5 g, respectively. Biomass production seedlings of sorghum variety Bachete with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown resulted in higher results than the control. Biomass production seedlings of sorghum variety Wagere with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown resulted in higher results than the control. Seedlings of the sorghum variety Wagere showed higher biomass compared to those in Bachete with striga at an equal concentration of inorganic fertilizer applied, as shown.

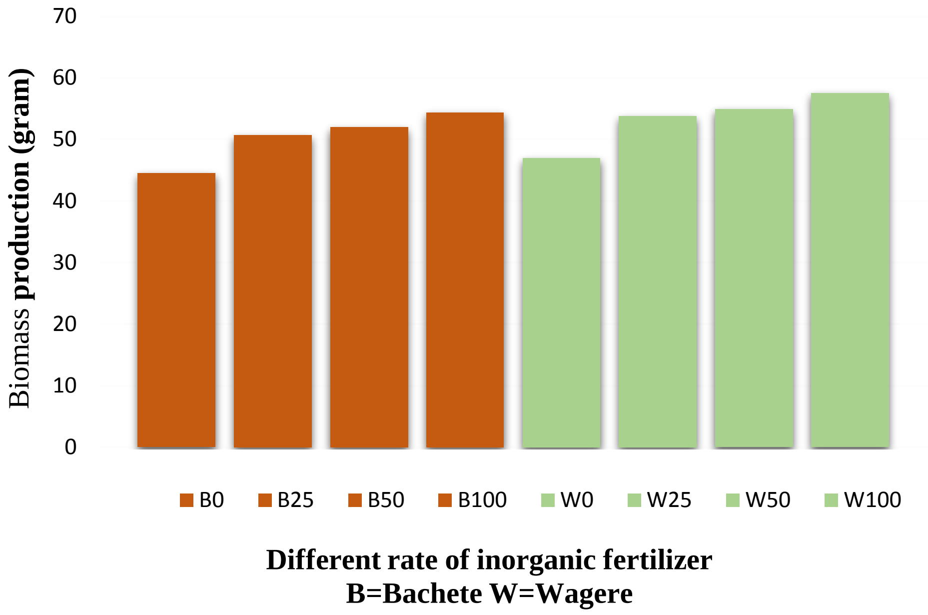


Figure 17: Biomass production yellow sorghum varieties Bachete (B) and Wagere (W) with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer

4.2.5 Use dry weight to shoot

The shoot dry weight showed a significant difference ($p \leq 0.05$) between seedlings of the sorghum variety Bachete with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer. The results were 43, 48, 49.1, and 51.3 g, respectively. Shoot dry weight seedlings of sorghum variety Wagere with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer. The results were 45, 49, 51, and 52.2 g, respectively. The shoot dry weight seedlings of the sorghum variety Bachete with striga at different concentrations of 25, 50, and 100% inorganic fertilizer obtained were higher than the control. The shoot dry weight seedlings of the sorghum variety Wagere with striga at different concentrations of 25, 50, and 100% inorganic fertilizer grown resulted in higher results than the control. Seedlings of the sorghum variety Wagere showed higher shoot dry weight compared to those in Bachete with striga at an equal concentration of inorganic fertilizer applied as shown.

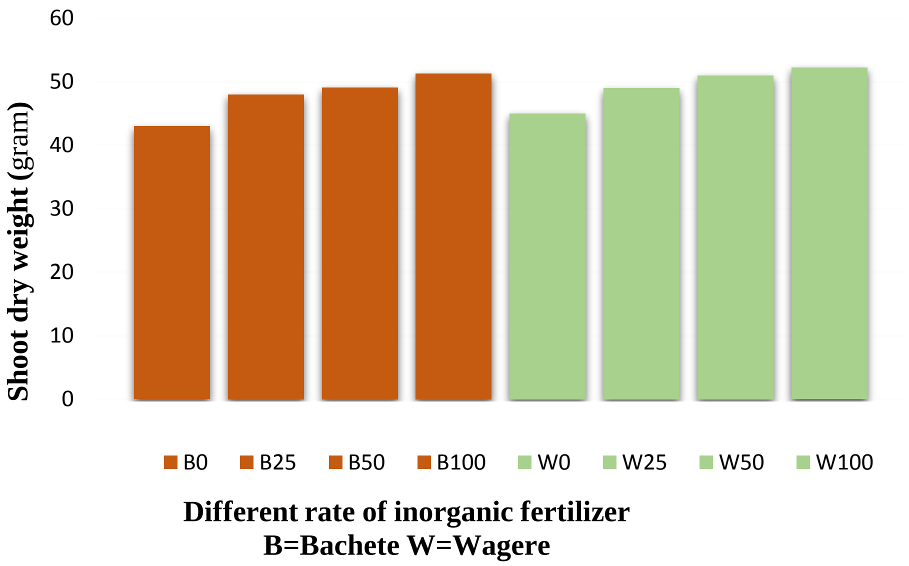


Figure 18: Shoot dry weight yellow sorghum varieties Bachete (B) and Wagere (W) with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer

4.2.6Use Dry weight to root

A significant difference was seen at ($p \leq 0.05$) root dry weight seedlings of the sorghum variety Bachete with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer. The grown results were 1.5, 2.7, 2.9, and 3.1 g, respectively. Root dry weight seedlings of sorghum variety Wagere with striga at different concentrations of 0, 25, 50, and 100% inorganic fertilizer grown resulted in 2, 4.8, 4.9, and 5.3 g, respectively. The root dry weight seedlings of the sorghum variety Bachete with striga at different concentrations of 25, 50, and 100% inorganic fertilizer obtained were higher than the control. The root dry weight seedlings of the sorghum variety Wagere with striga at different concentrations of 25, 50, and 100% inorganic fertilizer obtained were higher than the control. Seedlings of the sorghum variety Wagere showed a higher root dry weight compared to those in Bachete with striga at an equal concentration of inorganic fertilizer applied, as shown.

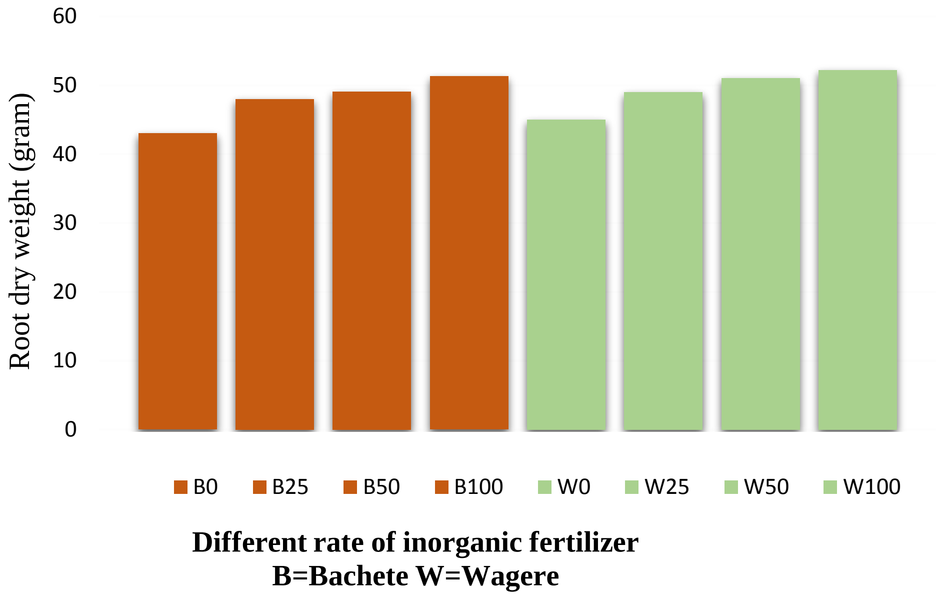


Figure 19: Root dry weight yellow sorghum varieties Bachete (B) and Wagere (W) with striga at different concentrations of 0, 25, 50 and 100% inorganic fertilizer

5. DISCUSSION

5.1Growth parameters of yellow sorghum varieties Bachete and Wagere with striga grown at different concentrations of inorganic fertilizer in a nursery bed.

5.1.1 Plant height

Plant height is a straightforward indicator of plant growth that is based on the quantity and length of functional nodes. Significant impacts of inorganic fertilizer on plant height were measured. Sorghum variety seedlings Bachete and Wagere at different concentrations of inorganic fertilizer grown result showed that plant height increased over the control (no inorganic fertilizer). Plants were longer in the experimental groups, probably because inorganic fertilizer was applied. Whereas the control group's minimum plant height. Plants in the control group were smaller, probably because no inorganic fertilizer was applied and due to the parasitic striga weed. A rise in plant height could likely be associated with nitrogen, phosphorus, and potassium vegetative growth-promoting effects, which increase the seedling height (Wang *et al.*, 2020). Maximum plant height result was recorded in seedlings of sorghum varieties Bachete and Wagere at 100% inorganic fertilizer applied due to recommended amount of inorganic fertilizer applied well for the growth of sorghum variety is added. Minimum plant height increment was recorded in seedlings of sorghum varieties Bachete and Wagere at 25% inorganic fertilizer applied due to below the recommended amount of inorganic fertilizer that is not sufficient for the growth of sorghum varieties. The result showed that seedlings of the sorghum variety Wagere had a higher plant height increment over the Bachete variety of sorghum at an equal concentration of inorganic fertilizer. As a result of the resistant variety of sorghum Wagere having resistant genes for striga attack. Hence, the resistant variety of sorghum Wagere is less susceptible to striga weed.

5.1.2 Leaf number (LN)

There was a significant difference on the total number of green leaves between treatments at $p < 0.05$ levels. The maximum leaf number was noted in seedlings of sorghum varieties Bachete and Wagere with striga at different concentrations of inorganic fertilizer applied, while the minimum leaf number was in the control. This indicates that inorganic fertilizer-containing soil could improve the total number of green leaves, whereas non-inorganic fertilizer-containing but striga-infected soil decreases the number of Green leaves. This is because inorganic fertilizer application has an effect on shoot count and reduces the emergence and reproduction of striga weed (Garba *et al*., 2017). The favorable impact of high nutrition availability may be the cause of this. It is clearily indicated that nitrogen, a component of chlorophyll, encourages the growth of vegetation and green foliage (Leghari *et al.*, 2016).

5.1.3 Leaf area (LA)

Seedlings of sorghum varieties Bachete and Wagere at different concentrations of inorganic fertilizer grown result showed that plant leaf area increased over the control. This is due to inorganic fertilizer, which contains N and is essential for leaf formation. LA provides a decent indication of the plant's photosynthetic potential. Regarding evapotranspiration, photosynthetic efficiency, nutrients, irrigation response, and plant development, it is a significant variable for the majority of eco-physiological research in terrestrial ecosystems (Mandila, 2021). This makes it a crucial parameter for comprehending photosynthesis, light interception, water and nutrient use, crop growth, and potential yield (Murchie & Burgess, 2022). It is also useful in studies of plant nutrition, plant competition, plant-soil-water relations, plant protection measurement, and heat transfer in plants (Gavrilescu, 2021). The current study has shown that, at various crop growth stages, inorganic fertilizer has a significant impact on sorghum's LA. The result showed that seedlings of the sorghum variety Wagere had a higher leaf area over the Bachete variety of sorghum at an equal concentration of inorganic fertilizer. As a result of the resistant variety of sorghum Wagere having resistant genes for striga attack. Hence, the resistant variety of sorghum Wagere is less susceptible to striga weed.

5.1.4 Radius of the root collar (RCD)

The diameter of the main stem measured at or close to the root collar is known as the root collar diameter, or RCD. In comparison to the control group, the largest RCD was found in Bachete and Wagere with striga at 100% inorganic fertilizer applications, respectively. The diameter of the seedling root collar grew by 29 percent after inorganic fertilization treatments (Deng *et al*., 2019). Both plant growth and root morphology are crucial criteria for assessing the impacts of provided nutrients, and nitrogen and phosphorus are major determinants of plant development and productivity (Razaq *et al*., 2017).

5.1.5 Number of seeds per plant

Seedlings of sorghum varieties Bachete and Wagere at different concentrations of inorganic fertilizer grown result showed that the number of seeds per plant increased over the control. The number of seeds planted increased over other treatments as a result of superior development characteristics brought about by the effective accumulation of desired food components and the lack of striga weed in the treatments. Grain yield was positively correlated with plant height (Farooq *et al.*,2022).Due to the parasitic influence of striga weed, there may have been fewer sorghum seeds in the control group (no inorganic fertilizer), which may have resulted in a fall in plant height and a decrease in panicle size and quantity of seeds per panicle.

5.1.6 Seeds weight

When 100% inorganic fertilizer was applied to seedlings of the sorghum types Bachete and Wagere, the maximum weight of seeds and thousand seeds was recorded, while the control group had the lowest value. Because yellow sorghum is a crop that responds well to phosphorus, its relatively low productivity could be improved with an appropriate supply of nutrients, particularly phosphorus (Prasad *et a*l., 2018).The result showed that seedlings of the sorghum variety Wagere had a higher plant height increment over the Bachete variety of sorghum at an equal concentration of inorganic fertilizer. As a result of the resistant variety of sorghum Wagere having resistant genes for striga attack. Hence, the resistant variety of sorghum Wagere is less susceptible to striga weed.

5.1.7 Biomass production

Seedlings of sorghum varieties Bachete and Wagere with striga at different concentrations of inorganic fertilizer grown had the highest biomass production over the control (no inorganic fertilizer). This occurred because there was a greater supply of N and P, which led to more photosynthetic accumulation and greater nutrient consumption from food. A balanced supply of key nutrients to the crop led to higher dry matter accumulation by plants, as documented by Rahman *et al.* (2014). Fertilization treatments enhanced the mean dry weight of the stems and leaves of the seedlings by 82. The result showed that seedlings of the sorghum variety Wagere had higher plant biomass production over the Bachete variety of sorghum at an equal concentration of inorganic fertilizer. Because the Wagere variety of sorghum is resistant to parasitic striga weed.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1CONCLUSIONS

The most important crop globally is sorghum. It is the third important crop next to teff and Maize in Ethiopia. It is tolerant to drought, heat and low nutrient. However, its production is highly constrained by the parasitic weed *striga hermonthica*. It attaches the host by its root like structure Haustorium causing wilting and stunted growth resulting devastating effect on the crop. Depending on the level of infestation entire crop loss may occur. Its infestation is sever when soil fertility, lack of resistant variety and drought low. Its effect is reversed by the use of inorganic fertilizer. It contains Macronutrients Nitrogen and phosphorus. Nitrogen and Phosphorus are important in chlorophyll formation and increases photosynthesis efficiency. As a result, it increases overall growth, development, and yield of sorghum. The use of inorganic fertilizers not only increases growth of sorghum but also reduces the infestation of weed striga. Therefore, with the application of inorganic fertilizer, the growth performances of yellow Sorghum could compute and dominate the growth and impact of Striga weed. Resistant Wagere variety of sorghum is remarkable effect in reducing striga infestation and enhancing crop production due to genes resistant to the weed. Finally, the most effective way of reducing striga infestation is the use of integrated striga control ways. These are: Hand weeding and sanitation, Crop rotation, Trap and Catheter crops, intercropping, soil fertility and push-pull technology.

6.2 RECOMMENDATIONS

1. Farmers use inorganic fertilizer (DAP and urea) to increase crop growth, development, and yield. The maximum grain yield and yield components of total biomass, head weight, and plant height were recorded prominently in plots treated with inorganic fertilizer. When Striga hermonthica weeds are present, sorghum crops perform better when inorganic fertilizer is applied. This is because inorganic fertilizer simultaneously improves host performance and lessens the intensity of Striga hermonthica weed assault. In general, applying a high dosage of inorganic fertilizer helps to delay the establishment of Striga hermonthica and achieve higher crop growth.

2. The most economical and successful control methods for striga are those that make use of high-yielding genotypes that are either striga-tolerant or striga-resistant. The most practical and workable approach to controlling striga would likely be to adopt resistant cultivars, especially for subsistence farmers in Ethiopia's striga-endemic regions. It has been discovered that the resistant sorghum variety Wagere shows promise in lowering striga-related yield losses. Similar to this, a low number of Striga m-2 was found in the resistant sorghum variety (wagere), which was noted for its incompatibility in responding to parasitic invasion, low production of the haustorial initiation factor, and low production of germination stimulant (LGS).
3. Different integrated striga control techniques, such as hand weeding and sanitation, crop rotation, intercropping, soil fertility, trap and catheter crops, and push-pull technologies, should be required of local farmers.

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APPENDECE

Appendix 1: Statistical evaluations of *S. bicolor*'s early growth characteristics and yield using ANOVA single factor

Plant height

B0	B25	B50	B100	W0	W25	W50	W100
11.5	13	14.5	15.5	13.5	14	15	16.5
37.5	44	48	51	42	47	49	54
75	90	100	106	85	95	105	110
100	133	140	150	120	140	145	160
110	142	150	160	125	150	163	170
120	150	160	170	130	160	170	180

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B0	6	454	75.66667	1862.167
B25	6	572	95.33333	3205.467
B50	6	612.5	102.0833	3537.642
B100	6	652.5	108.75	4023.575
W0	6	515.5	85.91667	2361.242
W25	6	606	101	3584.8
W50	6	647	107.8333	4075.367
W100	6	690.5	115.0833	4544.642
	0	0	#DIV/0!	#DIV/0!

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7045.917	8	880.7396	0.252612	0.977172	2.186685
Within Groups	135974.5	39	3486.526			
Total	143020.4	47				

INTERNODAL

B0	B25	B50	B100	W0	W25	W50	W100
18	22	25	30	20	22	27	32

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B0	1	18	18	#DIV/0!
B25	1	22	22	#DIV/0!
B50	1	25	25	#DIV/0!
B100	1	30	30	#DIV/0!
W0	1	20	20	#DIV/0!
W25	1	22	22	#DIV/0!
W50	1	27	27	#DIV/0!
W100	1	32	32	#DIV/0!

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	168	7	24	65535	#NUM!	#NUM!
Within Groups	0	0	65535			
Total	168	7				

LEAF NUMBER

B0	B25	B50	B100	W0	W25	W50	W100
3	3	3	3	3	3	3	3
6	7	7	7	6	7	7	7
7	8	8	8	7	8	8	8
7	9	9	9	7	9	9	9
8	11	11	11	8	11	11	11
9	13	13	13	9	13	13	13

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B0	6	40	6.666667	4.266667
B25	6	51	8.5	11.9
B50	6	51	8.5	11.9
B100	6	51	8.5	11.9
W0	6	40	6.666667	4.266667
W25	6	51	8.5	11.9
W50	6	51	8.5	11.9
W100	6	51	8.5	11.9

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	30.25	7	4.321429	0.432503	0.875935	2.249024
Within Groups	399.6667	40	9.991667			
Total	429.9167	47				

LEAF AREA

B0	B25	B50	B100	W0	W25	W50	W100
259.25	270	285	293	264.5	276.5	293.5	304

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B0	1	259.25	259.25	#DIV/0!
B25	1	270	270	#DIV/0!
B50	1	285	285	#DIV/0!
B100	1	293	293	#DIV/0!
W0	1	264.5	264.5	#DIV/0!
W25	1	276.5	276.5	#DIV/0!
W50	1	293.5	293.5	#DIV/0!
W100	1	304	304	#DIV/0!

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1731.18	7	247.3114	65535	#NUM!	#NUM!
Within Groups	0	0	65535			
Total	1731.18	7				

ROOT COLLAR DIAMETER

B0	B25	B50	B100	W0	W25	W50	W100
2.1	2.4	2.6	3.5	2.3	3.4	3.5	3.7

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B0	1	2.1	2.1	#DIV/0!
B25	1	2.4	2.4	#DIV/0!
B50	1	2.6	2.6	#DIV/0!
B100	1	3.5	3.5	#DIV/0!
W0	1	2.3	2.3	#DIV/0!
W25	1	3.4	3.4	#DIV/0!
W50	1	3.5	3.5	#DIV/0!
W100	1	3.7	3.7	#DIV/0!

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.93875	7	0.419821	65535	#NUM!	#NUM!
Within Groups	0	0	65535			
Total	2.93875	7				

PANICLE SIZE

B0	B25	B50	B100	W0	W25	W50	W100
30	40	50	60	35	45	55	70

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B0	1	30	30	#DIV/0!
B25	1	40	40	#DIV/0!
B50	1	50	50	#DIV/0!
B100	1	60	60	#DIV/0!
W0	1	35	35	#DIV/0!
W25	1	45	45	#DIV/0!
W50	1	55	55	#DIV/0!
W100	1	70	70	#DIV/0!

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1246.875	7	178.125	65535	#NUM!	#NUM!
Within Groups	0	0	65535			
Total	1246.875	7				

NUMBER OF SEEDS PER PLANT

B0	B25	B50	B100	W0	W25	W50	W100
1950	3430	3500	3540	2000	3590	3630	3680

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B0	1	1950	1950	#DIV/0!
B25	1	3430	3430	#DIV/0!
B50	1	3500	3500	#DIV/0!
B100	1	3540	3540	#DIV/0!
W0	1	2000	2000	#DIV/0!
W25	1	3590	3590	#DIV/0!
W50	1	3630	3630	#DIV/0!
W100	1	3680	3680	#DIV/0!

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3818600	7	545514.3	65535	#NUM!	#NUM!
Within Groups	0	0	65535			
Total	3818600	7				

SEEDS WEIGHT PER PLANT

B0	B25	B50	B100	W0	W25	W50	W100
95	126	128.1	129.8	100	130	132.2	132.6

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B0	1	95	95	#DIV/0!
B25	1	126	126	#DIV/0!
B50	1	128.1	128.1	#DIV/0!
B100	1	129.8	129.8	#DIV/0!
W0	1	100	100	#DIV/0!
W25	1	130	130	#DIV/0!
W50	1	132.2	132.2	#DIV/0!
W100	1	132.6	132.6	#DIV/0!

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1606.789	7	229.5413	65535	#NUM!	#NUM!
Within Groups	0	0	65535			
Total	1606.789	7				

THOUSAND SEEDS WEIGHT

B0	B25	B50	B100	W0	W25	W50	W100
35.5	39	39.4	41.8	36	41.8	43.7	44.8

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B0	1	35.5	35.5	#DIV/0!
B25	1	39	39	#DIV/0!
B50	1	39.4	39.4	#DIV/0!
B100	1	41.8	41.8	#DIV/0!
W0	1	36	36	#DIV/0!
W25	1	41.8	41.8	#DIV/0!
W50	1	43.7	43.7	#DIV/0!
W100	1	44.8	44.8	#DIV/0!

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	80.32	7	11.47429	65535	#NUM!	#NUM!
Within Groups	0	0	65535			
Total	80.32	7				

BIOMASS PRODUCTION

B0	B25	B50	B100	W0	W25	W50	W100
44.5	50.7	52	54.4	47	53.8	54.9	57.5

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B0	1	44.5	44.5	#DIV/0!
B25	1	50.7	50.7	#DIV/0!
B50	1	52	52	#DIV/0!
B100	1	54.4	54.4	#DIV/0!
W0	1	47	47	#DIV/0!
W25	1	53.8	53.8	#DIV/0!
W50	1	54.9	54.9	#DIV/0!
W100	1	57.5	57.5	#DIV/0!

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	130.42	7	18.63143	65535	#NUM!	#NUM!
Within Groups	0	0	65535			
Total	130.42	7				

THE SHOOT DRY WEIGHT

B0	B25	B50	B100	W0	W25	W50	W100
43	48	49.1	51.3	45	49	51	52.2

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B0	1	43	43	#DIV/0!
B25	1	48	48	#DIV/0!
B50	1	49.1	49.1	#DIV/0!
B100	1	51.3	51.3	#DIV/0!
W0	1	45	45	#DIV/0!
W25	1	49	49	#DIV/0!
W50	1	51	51	#DIV/0!
W100	1	52.2	52.2	#DIV/0!

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	71.095	7	10.15643	65535	#NUM!	#NUM!
Within Groups	0	0	65535			
Total	71.095	7				

ROOT DRY WEIGHT

B0	B25	B50	B100	W0	W25	W50	W100
1.5	2.7	2.9	3.1	2	4.8	4.9	5.3

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B0	1	1.5	1.5	#DIV/0!
B25	1	2.7	2.7	#DIV/0!
B50	1	2.9	2.9	#DIV/0!
B100	1	3.1	3.1	#DIV/0!
W0	1	2	2	#DIV/0!
W25	1	4.8	4.8	#DIV/0!
W50	1	4.9	4.9	#DIV/0!
W100	1	5.3	5.3	#DIV/0!

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	14.22	7	2.031429	65535	#NUM!	#NUM!
Within Groups	0	0	65535			
Total	14.22	7				

Appendix2:Nursery bed preparation Soils filled in plastic bags

Appendix3:DAP and Urea were added in the soil Bachete and Wagere were sowed

Appendix4:Wagere Variety of sorghum Bachete Variety of sorghum

Appendix5:Seeds were germinated Growth parameters were measured every 15 days

Appendix6:30 days old Bachete and Wagere 75 days old Bachete and Wagere

Appendix7:90 days old Bachete and Wagere Leaf area were measured using graph paper